

# Financial Distortions and the Distribution of Global Volatility

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## Abstract

Why are emerging economies excessively vulnerable to shocks to external funding? What was the role of financial flows from emerging to developed economies in setting the stage for the subprime crisis? This paper addresses these questions in a simple general equilibrium framework that emphasizes the aggregate implications of the misallocation of funds on the micro level. The analysis shows that the misallocation of funds amplifies volatility even in a closed economy. Financial integration between relatively distorted emerging economies and relatively undistorted developed economies leads to

a further divergence in volatility, thereby providing a new and simple explanation for the divergent trends in output volatility up to the recent crisis. In the integrated environment, cheap funding leads to an endogenous deterioration of the financial system in developed economies. These predictions are consistent with a wide variety of microfoundations, in which distortions cause productive projects to be relatively more sensitive to aggregate shocks. The paper provides some empirical evidence for these microfoundations.

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# Financial Distortions and the Distribution of Global Volatility

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# 1 Introduction

The patterns of global volatility over the last few decades have raised many questions regarding the consequences of globalization. For emerging economies, financial integration was typically associated with episodes of extreme volatility, often related to fluctuations in the supply of external funding. At the same time, for developed economies, fluctuations in the supply of funds did not seem to be an important source of volatility, at least not until the recent crisis<sup>1</sup>. Further, evidence suggests that the relative importance of non-technology shocks in developed economies was declining over the period of financial globalization, as many attributed the “Great Moderation” trend in output volatility to a decline in non-fundamental volatility<sup>2</sup>. Why were the initial effects of financial integration so different for emerging and developed economies?

The picture is complicated further by the recent crisis, that suggests that the consequences of financial integration on volatility in developed economies may have been highly complex. While fluctuations in external funding were not an important driver of volatility during normal times, it seems that the magnitude of flows towards developed economies may have led to an overflow of the financial system and a collapse from within. Many attribute the amplification of the crisis to the incapacity of the financial system to withstand even relatively small shocks, a fragility that was an equilibrium outcome of a global environment that flooded the financial system with liquidity. Did the global supply of funds play a role in setting the stage for the sub prime crisis?

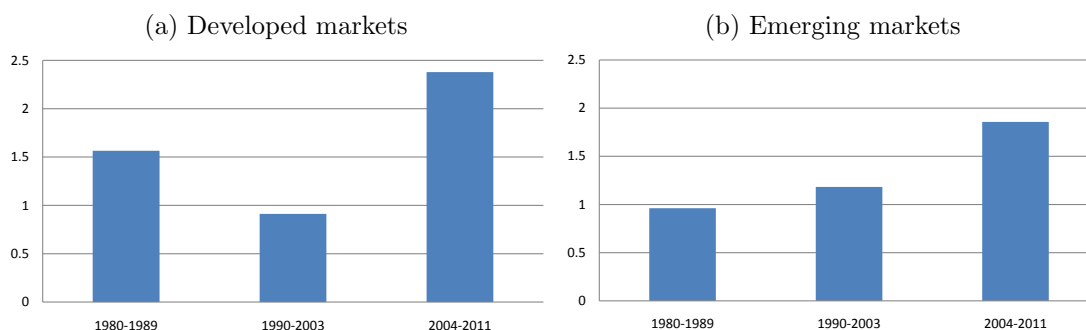
This paper takes the view that the aggregate implications of financial distortions are central to these questions. I consider a model in which funding is the single input of production, and there are heterogeneous projects. Distortions increase the sensitivity of relatively productive projects to aggregate fluctuations in the supply of funds. In reduced form, this type of misallocation can be represented as a

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<sup>1</sup>See Demirguc-Kunt and Detragiache [1999], Kose et al. [2003] and Bekaert et al. [2006] for an empirical discussion of the differential effects of financial integration on emerging and developed economies. For literature emphasizing the importance of shocks to external funding to volatility in emerging markets, see Neumeyer and Perri [2005], Uribe and Yue [2006], Chang and Fernandez [2010] and Broner and Ventura [2010], among others.

<sup>2</sup>See Gali and Gambetti [2009] for a structural VAR decomposition of the components of the “Great Moderation”.

Figure 1: The Standard Deviation of Output Growth



The calculations are based on data from the IMF’s World Economic Outlook, September 2011. The calculation for developed markets are based on the series “Advanced Economies”, and the calculation for emerging markets are based on the series “Emerging and Developing Economies”. Growth rates are calculated based on the cumulative output produced by all countries in the group.

This figure plots the standard deviation of output growth in developed and emerging economies during three periods: the “pre-integration” period (1980-1989), the “integration” period (1990-2003) and the “post-integration” period (2004-2011) (see Chinn and Ito [2008] for a discussion of the timing of financial globalization). Two stylized facts are illustrated: (i) the initial divergence in volatility between emerging and developed economies upon financial integration, as illustrated by the decline in output volatility in developed economies between the periods 1980-1989 and 1990-2003, and the increase in output volatility in emerging economies over the same time; and (ii) the spike in volatility in both regions in the post integration period, that includes the subprime crisis.

less steeply declining aggregate marginal return to funds: in efficient economies, projects are implemented in an order decreasing in their returns. The aggregate marginal return to funds is decreasing, as less and less productive projects are funded as the supply of funds increases. In distorted economies, the order in which projects are implemented is less correlated with their productivity. The marginal return to funding declines less steeply, as relatively productive projects are implemented with the marginal units of funding, while relatively unproductive projects are implemented inframarginally.

I embed this reduced form representation of distortions in a stylized general equilibrium model of financial integration. I begin by studying the closed economy equilibrium, and illustrate a tight link between financial distortions and aggregate output volatility. Shocks to the aggregate supply of funds are amplified by financial distortions, as distortions increase the vulnerability of relatively productive projects to aggregate fluctuations.

Next, I consider a global environment with a “distorted” emerging market region and an “efficient” developed market region, and characterize the integrated equilibrium under the short run assumption that the levels of distortion remain fixed. I show that financial integration leads to a further divergence in volatility between the two regions. In equilibrium, fluctuations in the global supply of funds adjust disproportionately through changes in the amount of funding supplied to emerging markets: an expansion in the supply of funds would lead to a larger expansion in emerging economies, as the projects implemented at the margin yield relatively higher returns. At the same time, a contraction in the supply of funds would lead to a larger contraction in emerging economies, as the set of projects funded inframarginally yield a relatively lower return. This presents a new and simple explanation for the divergence in volatility trends up to the recent crisis, based on an intuitive “conservation of volatility” law: the equilibrium counterpart of the increase in volatility in emerging economies is a decline in volatility in developed economies, as shocks to the domestic liquidity supply in developed economies adjust primarily through changes in the amount of funding supplied to emerging markets.

Finally, I study the medium run equilibrium in which the quality of the financial system in the developed world endogenously adjusts to the integrated environment.

I extend the model to allow banks to choose the level of distortion, where a higher level of distortion is associated with a lower cost. When financial integration is associated with a large drop in the price of funding, banks endogenously select a higher level of distortion. Intuitively, when funding is cheap, most projects should be implemented anyway; the returns to sustaining institutions that enable the differential contraction of productive and unproductive projects goes down. Interestingly, these endogenous institutional changes have a mixed effect on output and output volatility. While the output response to large contractions in the supply of funds is amplified, the deterioration in the financial system actually serves to increase and stabilize output during normal times. In the extreme case, the financial system implements all projects, regardless of small fluctuations in the price of funding, resulting in high and stable output. However, when the supply of funds contracts so much that the economy can no longer afford to run at full capacity, there is an efficiency loss resulting from the economy's inability to absorb contractions through the discontinuation of the least productive projects.

The model's predictions depend crucially on the assumption that the marginal return to funding is declining less steeply in more distorted economies. Formally, the key assumption is that the marginal return to funding is log supermodular in funding and the level of distortion. To assess the relevance of this assumption, one can ask (i) under which microfoundations it will hold and (ii) whether or not these microfoundations are themselves empirically relevant. I show that this assumption arises naturally in a wide variety of models in which the equilibrium is characterized by a stochastic matching between funding priorities and projects. Distortions create a mismatch, making better projects less likely to receive high priority, and relatively worse projects relatively more likely to receive a higher priority. I present empirical evidence for these properties using firm level data from emerging and developed economies. I find that in emerging economies, productive firms are relatively more sensitive to fluctuations in the aggregate supply of funds, and that the opposite is true for relatively less productive firms. I show that this type of mismatch can arise from many common sources of distortions, such as incomplete information, inefficient government intervention, collateral constraints and search frictions.

## 2 Related literature

The results concerning the divergence in volatility between emerging and developed economies are related to several strands of literature. The idea that financial distortions exacerbate output volatility appears prominently in the context of collateral constraints. Kiyotaki and Moore [1997], Fostel and Geanakoplos [2008] and Caballero and Krishnamurthy [2001] are important examples, the latter two with specific applications to emerging market economies. The general formulation in this paper suggests that the link between financial distortions and volatility is not unique to collateral constraints, and is common to many forms of distortions. The mechanism in this paper is closest to Kiyotaki and Moore [1997], as the amplification of shocks is a result of a domestic inefficient allocation of resources that causes relatively productive projects to be more sensitive to aggregate fluctuations. However, the role of external funding in explaining emerging market volatility is closest to Fostel and Geanakoplos [2008]. In Fostel and Geanakoplos [2008], a small group of constrained investors hold emerging market assets. Shocks to the liquidity in the hands of these investors evidently translate into movements in the liquidity supply for emerging market projects. The focus of this paper is complementary to the one in Fostel and Geanakoplos [2008]: while their starting point is that emerging market projects are funded by a small group of “residual” investors, this paper uses financial distortions to endogenize the assumption that emerging market projects are “residual”.

Also related is the literature on volatility, development, and openness. The result that economies in earlier stages of development become more volatile with financial integration is in line with Obstfeld [1994], Greenwood and Jovanovic [1990], and Koren and Tenreyro [2009]. The focus in these papers is on the changes in the sectoral composition induced by better consumption diversification opportunities. If financial integration allows for better diversification, investors may be more inclined to take on high-risk projects, potentially increasing the aggregate riskiness of the economy. This mechanism is very different from the mechanism discussed in this paper, which does not rely on changes in sectoral composition. While sectoral composition seems like a plausible source for some shocks, particularly in lower stages of development, it seems like an unlikely explanation for



the heightened volatility of emerging markets associated with movements in external funds (such as sudden stops). Moreover, it provides a poor explanation for the common movements in emerging market economies, which have very different sectoral compositions.

Conceptually related is the work of Caballero et al. [2008], who study global imbalances as an outcome of financial integration in a world with heterogeneous financial development. While the questions motivating these papers are different, both share the view that integration with a financially underdeveloped region is an important factor behind recent trends in the US economy. The work of Fogli and Perri [2006] links the Great Moderation with global imbalances by arguing that global imbalances are a natural artifact of the decline in volatility. In their model, the decline in volatility (relative to the rest of the world) reduces households' relative incentives to accumulate precautionary savings. This paper proposes an alternative link between financial integration and the Great Moderation. In this model, financial integration decreases volatility in the developed world and increases volatility in emerging markets; it could be that as a result, through the mechanism in Fogli and Perri [2006], the external balance of the developed markets deteriorates. This combined mechanism demonstrates an additional channel through which financial underdevelopment in emerging markets may translate into global imbalances.

The results concerning the endogenous deterioration of the financial system in the developed world are broadly related to the literature on bubbles. As shown in Tirole [1985], environments in which the interest rate is low are fertile grounds for the formation of bubbles, and the presence of bubbles may lead to an expansion in output (as in Farhi and Tirole [2010] and Martin and Ventura [2010]). However, the mechanisms through which a low interest rate leads to an expansion are different: in the bubble literature, bubbles serve as additional sources of liquidity, which enable more economic activity. In this paper, low interest rates are indicative of a situation in which the global supply of liquidity is already high; the expansion results from an endogenous decision of intermediaries to implement projects indiscriminately, increasing the total amount of projects implemented.

Similar to the bubble-burst view of the crisis, this paper takes the view that the root of the crisis is a sudden contraction in the supply of liquidity. The contraction

in the supply of liquidity is not modeled here explicitly, and may be thought of as resulting from a burst of a bubble on an asset used for liquidity purposes (see Holmstrom [2008]). However, unlike the bubble-burst view of the crisis, in this model the burst of the bubble itself does not explain the full extent of the crisis. Rather, the crisis is amplified by the structural changes that the financial system underwent during the expansionary period. The emphasis on the role of financial frictions as an amplification mechanism of the crisis is shared with Hall [2009], Gertler and Kiyotaki [2010], and others. The view closest to this paper is the one expressed in Brunnermeier [2009] and Gorton [2008]. These papers discuss mechanisms through which a low interest rate environment led to a decline in lending standards and institutional changes which evidently amplified the subprime crisis. The model presented in this paper may be seen as a simple formalization grouping these phenomena.

This paper is also related to the empirical literature on the macroeconomic consequences of misallocation. Closest to this paper is Hsieh and Klenow [2009]. Similar to this paper, Hsieh and Klenow [2009] conduct an empirical study of the aggregate consequences of misallocation, without taking a stance on the type of distortion that causes resources to be allocated inefficiently. However, Hsieh and Klenow [2009] focus on the static productivity loss induced by misallocation, whereas I focus on the volatility induced by misallocation, or the amplification of contractions caused by the discontinuation of relatively productive projects.

Methodologically, this paper is related to the literature emphasizing the role of supermodularity and log supermodularity conditions in various economic fields. Prominent examples include, among others, Milgrom and Weber [1982] in auction theory; Bulow et al. [1985] in industrial organization; Jewitt [1987] and Athey [2002] in monotone comparative statics under uncertainty; and Costinot [2009] in international trade. Shimer and Smith [2000] consider a model in which heterogeneous agents search for partners for joint production, where the output produced by the match depends positively on each type. They use log supermodularity conditions on the joint production function to generate sufficient conditions for positive assortative matching. Broadly, the model in this paper is the inverse exercise: I characterize conditions on the matching process that deliver log supermodularity of the aggregate production function.

### 3 An aggregate representation of misallocation

There is a single consumption good and a single input of production called *funding* and denoted  $F \in [0, 1]$ . Of course, this is a shortcut for a richer model in which funding is used to hire workers, rent capital and buy intermediate inputs. Fluctuations in  $F$  can therefore be interpreted as fluctuations in employment; when  $F = 1$ , all inputs are employed.

There is a set of *projects* indexed  $x \in [0, 1]$ . Each project requires one unit of funding to implement. Projects are of heterogeneous productivity: if implemented, the project indexed  $x$  produces  $Ag(x)$  units of output, where  $A$  is the aggregate component of productivity and  $g(x)$  is the idiosyncratic component of productivity. Without loss of generality, I assume that  $g'(x) \leq 0$ , so projects with lower indices are more productive.

Whether or not a project is implemented depends on the whether the aggregate supply of funding is high enough. For each project  $x$ , there is a threshold  $p = p(x)$ , such that the project is implemented if and only if  $F \geq p$ . In principle, this threshold is an equilibrium object that is determined by a wide variety of factors, including the project's productivity, its collateral, its connections to people in power, etc. Importantly for our purposes, this equilibrium object can be summarized as a *funding priority*: when the aggregate supply of funds is  $F$ , all projects with funding priorities  $p \in [0, F]$  are implemented.

The financial system is represented by a stochastic matching between funding priorities and projects. Let  $\phi$  be a reduced form parameter capturing the level of distortion. A higher  $\phi$  corresponds to a more distorted allocation. In an economy with distortion level  $\phi$ , the probability that project  $x$  receives priority  $p$  is given by  $\sigma_\phi(x, p)$ .

Aggregate output is denoted  $Y$ . I assume that the matching takes place simultaneously in many different sub-locations, so aggregate output is deterministic and equal to the expected output produced by all implemented projects, that is, all projects with priorities  $p \leq F$ :

$$Y(A, F, \phi) = \int_0^F \int_0^1 \sigma_\phi(x, p) Ag(x) dx dp \quad (1)$$

The aggregate marginal return to funding, denoted  $y$ , is given by:

$$y(A, F, \phi) = Ay(F, \phi) = \frac{\partial Y(A, F, \phi)}{\partial F} = \int_0^1 \sigma_\phi(x, F) Ag(x) dx \quad (2)$$

I assume that better projects are relatively more likely to receive high priorities, so the marginal return to funding is weakly decreasing ( $\frac{\partial y(F, \phi)}{\partial F} \leq 0$ ).

The key ingredient in the model is the following property, that states that the marginal return to funding is log supermodular<sup>3</sup> in the level of funding and the level of distortion:

**Property 1** *For any  $\phi \geq \phi'$  and for any  $F \geq F'$ ,*

$$\frac{y(F, \phi')}{y(F', \phi')} \leq \frac{y(F, \phi)}{y(F', \phi)} \quad (3)$$

Property 1 can be understood as follows. Fix any two levels of funding,  $F'$  and  $F$ , such that  $F' \leq F$ . Property 1 requires that the ratio of the marginal returns to funding at  $F$  and  $F'$  is relatively lower in more efficient economies; loosely stated, the (negative) slope of the marginal return to funding is relatively more steep in more efficient economies.

This simple setup is sufficient for producing all of the macroeconomic insights that follow. To motivate Property 1, in section 7 I show that it is consistent with a wide variety of standard microfoundations, including models of informational frictions, collateral constraints, inefficient government intervention and search frictions. The common feature of these microfoundations is that distortions cause relatively more productive projects to receive lower funding priorities, making their implementation outcome more sensitive to changes in  $F$ .

For the time being, consider the following stark microfoundation, that will be used to illustrate the results throughout the paper:

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<sup>3</sup>Recall that a function  $f(x_1, x_2)$  is log supermodular in  $x_1$  and  $x_2$  if for any  $x'_1 < x_1$  and  $x'_2 < x_2$ , we have that  $f(x_1, x_2)f(x'_1, x'_2) \geq f(x'_1, x_2)f(x_1, x'_2)$ . If  $f$  is strictly positive, this condition implies that  $\frac{f(x_1, x'_2)}{f(x'_1, x'_2)} \leq \frac{f(x_1, x_2)}{f(x'_1, x_2)}$ . If  $f$  is strictly positive and differentiable, this corresponds to  $\frac{\partial^2 \ln f(x_1, x_2)}{\partial x_1 \partial x_2} \geq 0$ .

**Random allocation example.** There are two types of economies: efficient (*eff*) and distorted (*dis*). In efficient economies, projects are implemented in the order of their productivity; the funding priority of project  $x$  is  $p(x) = x$ . This means that the probability of being assigned priority  $p = F$  is 0 for all  $x \neq F$ , and 1 for  $x = F$ :

$$\int_0^x \sigma_{eff}(z, F) dz = \begin{cases} 0 & \text{If } x < F; \\ 1 & \text{If } x \geq F. \end{cases} \quad (4)$$

Given an aggregate supply of  $F$  units of funding, output is given by the cumulative output produced by the  $F$  best projects:

$$Y_{eff}(F) = \int_0^F Ag(x) dx \quad (5)$$

The marginal return to funding is given by the productivity of the marginal project:

$$y_{eff}(F) = Ag(F) \quad (6)$$

In distorted economies, projects are implemented in an arbitrary order. The probability that priority  $p = F$  is assigned to project  $x$  is constant:

$$\int_0^x \sigma_{dis}(z, F) dz = x \quad (7)$$

This randomness can be thought of as resulting from a wide range of distortions; for example, it could be that the financial sector lacks the expertise to evaluate projects, and must implement projects arbitrarily. Alternatively, the randomness could be indicative of an economy with extreme corruption, in which the implementation outcome is orthogonal to productivity.

Output is equal to the expected cumulative output produced by  $F$  randomly drawn projects:

$$Y_{dis}(F) = F \cdot \int_0^1 Ag(x) dx \quad (8)$$

The marginal return to funding is constant and equal to the average return to projects:

$$y_{dis}(F) = \int_0^1 Ag(x) dx \quad (9)$$

It is easy to see that this model is consistent with Property 1, as the marginal return to funding is declining in efficient economies, but constant in distorted economies. Formally, it is easy to check that for any  $F' \leq F$ :

$$\frac{y_{eff}(F)}{y_{eff}(F')} = \frac{Ag(F)}{Ag(F')} \leq 1 = \frac{\int_0^1 Ag(x)dx}{\int_0^1 Ag(x)dx} = \frac{y_{dis}(F)}{y_{dis}(F')} \quad (10)$$

## 4 Closed economy equilibrium

In this section I characterize the effects of financial distortions on volatility under autarky, and show that more distorted economies are more sensitive to fluctuations in the aggregate supply of funding.

In the closed economy, the supply of funding is given by an exogenous domestic liquidity supply,  $Q$ . Domestic households supply liquidity to the financial system, in exchange for future returns. In this model, liquidity is defined simply as the supply side of funding. The market clearing condition is:

$$F = Q \quad (11)$$

After production takes place, the financial system repays households at a rate of  $r$  units of output per unit of liquidity. I assume that  $r$  is equated with the marginal return to funding. This can be thought of as a result of a competitive banking system in which banks compete for liquidity supply from households.

There are two sources of volatility: shocks to the domestic technology level  $A$ , and shocks to the supply of liquidity,  $Q$ . I assume that these shocks are independent<sup>4</sup>. Appendix C presents a model of liquidity supply in which liquidity supply fluctuations are driven by three primitive shocks: shocks to the money supply, shocks to risk aversion, and shocks to the ability of the private sector to generate promises for future repayment.

It is straightforward to show that, in the closed economy, the sensitivity of

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<sup>4</sup>The assumption that shocks to  $A$  and to  $Q$  are independent is, of course, unrealistic, as periods of high productivity may imply that it is easier for entrepreneurs to issue promises on future returns, as in Kiyotaki and Moore [1997]. The independence of the two shocks is not necessary for any of the results, however separating the two types of shocks is convenient for expositional purposes.

output to productivity shocks is unrelated to the degree of financial distortions. However, more distorted economies are more sensitive to shocks to liquidity supply:

**Proposition 1** *For any given processes of  $A$  and  $Q$ ,*

1. *Output is more volatile in more distorted economies:*

$$\frac{\partial \ln Y(Q, \phi)}{\partial \ln Q} \text{ is increasing in } \phi \quad (12)$$

2. *The average productivity of funded projects is more sensitive to liquidity supply shocks in less distorted economies:*

$$\frac{\partial \frac{Y(Q, \phi)}{Q}}{\partial \ln Q} \text{ is increasing in } \phi \quad (13)$$

The proof of the above proposition, together with other omitted proofs, is in the appendix. The intuition follows directly from Property 1. In efficient economies, the decline in the average productivity of projects mitigates the effect of an increase in funding. In distorted economies, a suboptimal set of projects is implemented, so some low-yield projects are implemented before higher-yield projects. This implies two things. First, some projects that should have been implemented are not implemented; their implementation takes place only when the supply of funding is higher, intensifying the returns to funding. Second, some projects that should not have been implemented are implemented, lowering the average productivity of funded projects. These two facts put together imply that the ratio of the marginal return to funding and the average return to funding is higher in distorted economies. In other words, liquidity abundance increases the efficiency of distorted economies relative to efficient economies both by alleviating the inefficiency caused by implementing a suboptimal set of projects and by allowing for the implementation of higher-yield projects. Using the random allocation example, figure 2 illustrates the properties of the closed economy equilibria in a distorted “emerging market” economy and an efficient “developed market” economy.

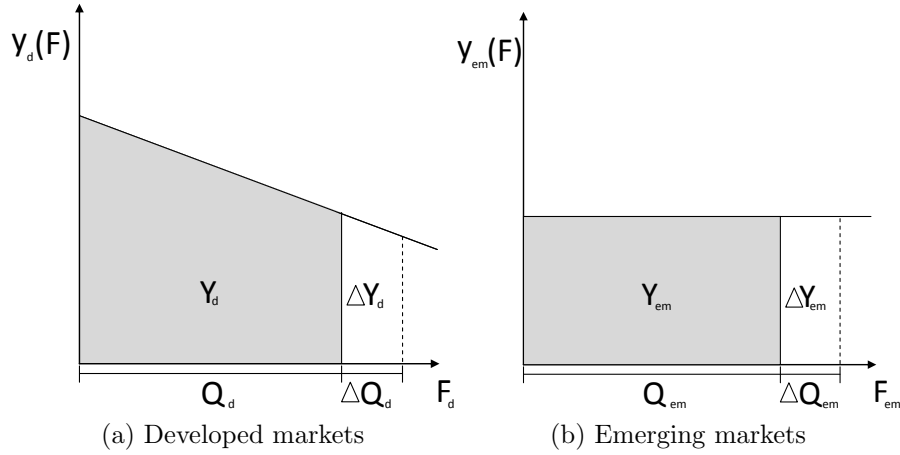


Figure 2: The figure on the left depicts the closed economy equilibrium in efficient “developed” economies, and the figure on the right depicts the closed economy equilibrium in distorted “emerging” economies. In both economies there is a positive shock to liquidity supply. The average productivity declines in efficient economies and remains constant in distorted economies. The output response is therefore larger in distorted economies (in the sense that  $\frac{\Delta Y}{Y}$  is larger).

## 5 Volatility divergence

In this section I present a set of results concerning the divergence of volatility between emerging and developed economies following financial integration. I first present the globally integrated equilibrium, and then discuss equilibrium implications for small open economies.

The setup of the model is as follows. There are two regions of equal size: an emerging market region ( $em$ ) and a developed market region ( $d$ ). For the time being, I assume that the only difference between emerging and developed economies is that emerging economies are more distorted than developed economies:

$$\phi_{em} > \phi_d \tag{14}$$

For simplicity, I denote  $Y_i = Y(A_i, F_i, \phi_i)$  and  $y_i = y(A_i, F_i, \phi_i)$ , for  $i \in \{em, d\}$ .

I assume that  $var(\ln(A_d)) = var(\ln(A_{em}))$ <sup>5</sup> and that liquidity supply  $Q_i$  is independent from both foreign and domestic technology,  $A_i$  and  $A_j$ .

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<sup>5</sup>The results trivially generalize to  $var(\ln(A_d)) < var(\ln(A_{em}))$ .



In order to isolate the effects of financial heterogeneity on the global equilibrium environment, it is convenient to assume that  $Q_d$  and  $Q_{em}$  are perfectly correlated. Assuming that liquidity supplies are perfectly correlated isolates the effects of financial heterogeneity because, under this assumption, financial integration between two *identical* economies would have no effect on liquidity-supply driven output volatility. In contrast, independent liquidity supplies would imply that financial integration between two identical regions has a moderating effect on output in both regions, as shocks to liquidity supply are shared across regions. Replacing the assumption that  $Q_d$  and  $Q_{em}$  are perfectly correlated with the assumption that they are independent would therefore decrease volatility in both regions; however, the result that volatility induced by financial integration would be relatively higher for emerging economies would still hold.

## 5.1 Integrated equilibrium

Assume that liquidity can move freely across regions. The global equilibrium is characterized by two equations:

$$F_{em} + F_d = Q_{em} + Q_d = Q_w \quad (15)$$

$$y_{em}(F_{em}) = y_d(F_d) = r \quad (16)$$

The first equation is a market clearing condition, stating that the total amount of funding,  $F_{em} + F_d$ , must be equal the global supply of liquidity,  $Q_w = Q_{em} + Q_d$ . The second condition is the optimality condition of the financial system, requiring that there is no gain from reallocating liquidity from one region to another<sup>6</sup>.

I denote autarkic values with superscript  $a$  ( $F^a$ ,  $Y^a$ , etc). Denote by  $\Delta$  the absolute value of the *average* change in funding levels induced by financial integration:

$$\Delta = |E(F_{em}) - E(F_{em}^a)| = |E(F_d) - E(F_d^a)| \quad (17)$$

The value of  $\Delta$  is determined in equilibrium as a function of the average sup-

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<sup>6</sup>The results easily generalize if there is a constant wedge in marginal returns, that is, the second equilibrium condition is replaced with a condition of the form  $y_d(F_d) = wy_{em}(F_{em})$

ply of liquidity, the financial distortions, and the relative productivities  $\frac{A_d}{A_{em}}$ . In particular, there is always a value of  $\frac{A_d}{A_{em}}$  for which  $\Delta = 0$ . For the purpose of this exercise, I assume that  $\Delta$  is small. The importance of this assumption is in assuring that the sensitivity of output to funding remains similar to its autarkic level. If this assumption is violated, the implications of financial integration on macroeconomic volatility depend more specifically on how the sensitivity of output with respect to funding changes with the level of funding.

The main result is stated in the proposition below:

**Proposition 2** *For  $\Delta$  sufficiently small, financial integration exacerbates the volatility differences between emerging and developed markets:*

$$var(\ln F_{em}) - var(\ln F_d) > var(\ln F_{em}^a) - var(\ln F_d^a) = 0 \quad (18)$$

$$var(\ln Y_{em}) - var(\ln Y_d) > var(\ln Y_{em}^a) - var(\ln Y_d^a) > 0 \quad (19)$$

Financial integration leads to a divergence in volatility levels for two reasons<sup>7</sup>. First, financial integration is associated with a new source of fluctuations in funding, which is shocks to the relative productivity of emerging and developed economies ( $\frac{A_{em}}{A_d}$ ). These shocks lead to a substitution of funding across regions. Since, by proposition 1, financially-distorted emerging markets are more sensitive to fluctuations in funding than developed markets, this works towards exacerbating the differences in output volatility across regions.

Second, it turns out that shocks to the global supply of liquidity adjust disproportionately through changes in the supply of funding to emerging markets. This equilibrium property is closely related to the feature of financial distortions emphasized by Property 1. In developed markets, projects are implemented in an order decreasing in their returns: most implemented projects generate returns which well exceed  $r$ , while most unimplemented projects generate returns which are well below  $r$ . Fluctuations in the implementation threshold therefore have a relatively small impact on the amount of projects implemented in developed

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<sup>7</sup>Proposition 2 easily generalizes to an equilibrium with many countries with different levels of distortions. In an integrated equilibrium, the sensitivity of each economy to shocks to the global supply of liquidity or to TFP will be an increasing function of its level of financial distortions. Differences in volatility levels will magnify upon financial integration.

economies. In contrast, in emerging markets, the order in which projects are implemented is more arbitrary; this implies that the return generated by the next unit of funding is similar to the return generated by the previous unit. The same fluctuations in  $r$  therefore induce larger fluctuations in the amount of implemented projects. Figure 3 illustrates this equilibrium property in the random allocation example<sup>8</sup>.

Generically, abstracting from productivity shocks, financial integration leads to less variation in  $r$  from the developed market's perspective, and more variation in  $r$  from the emerging market's perspective. Consequently, there is a divergence in liquidity-driven output volatility between emerging and developed economies.

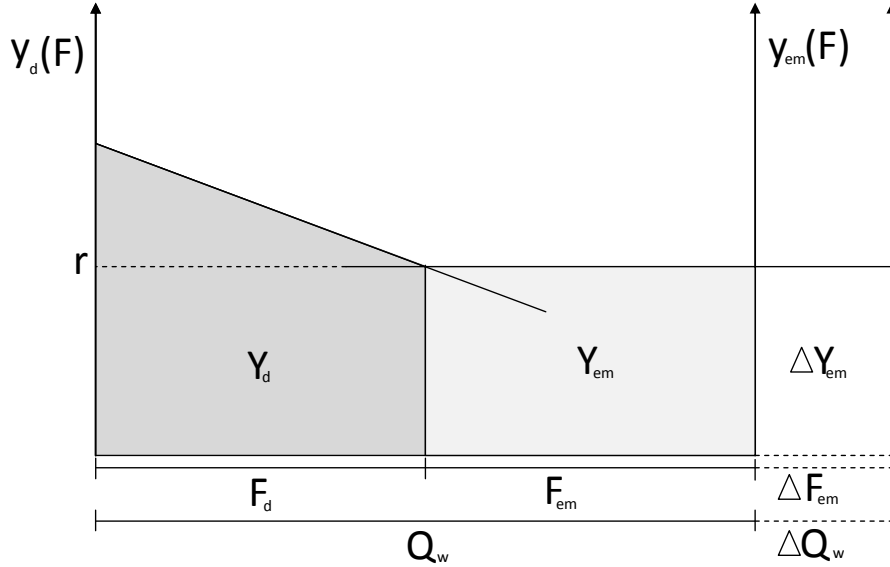


Figure 3: In this figure, the origin of the developed economy is on the left corner, and the origin of the emerging economy is on the right corner. The market clearing condition states that the distance between the two corners is equal to the global liquidity supply,  $Q_w$ . The intersection of the marginal returns to funding determines  $r$ , and hence the division of  $Q_w$  into  $F_d$  and  $F_{em}$ . Shocks to the global liquidity supply adjust entirely through changes in the funding levels supplied to emerging markets,  $F_{em}$ . An increase in  $Q_w$  of size  $\Delta Q_w$  is illustrated as a shift of the emerging economy's origin to the right.

The direction in which volatility levels change following financial integration is

<sup>8</sup>In the random allocation example, the equilibrium level of  $r$  does not change following a shock to global liquidity supply. Rather, the shock is adjusted entirely through changes in the quantity of funding supplied to the emerging market region.

potentially different in emerging and developed economies. In emerging economies, the volatility of funding necessarily increases upon integration. This is because funding becomes vulnerable to two new shocks: shocks to foreign liquidity supply ( $Q_d$ ) and shocks to relative technology levels ( $\frac{A_{em}}{A_d}$ ). In developed economies, funding also becomes vulnerable to shocks to relative technology, which works towards increasing volatility. However, funding becomes less sensitive to shocks to domestic liquidity supply ( $Q_d$ ), since shocks to liquidity supply adjust primarily through movements in the funding supplied to emerging markets. The net effect on volatility depends on the relative importance of technology shocks and liquidity shocks. Specifically, if movements in the level of funding result primarily from variation in the supply of liquidity, financial integration will decrease the volatility of output in developed economies.

Under stronger assumptions regarding the relative importance of liquidity and technology shocks, it is possible to obtain stronger results concerning the direction in which volatility levels change following financial integration:

**Proposition 3** *For  $\Delta$  sufficiently small,*

1. *Financial integration increases the volatility of funding and the volatility of output in emerging markets:*

$$\text{var}(\ln F_{em}) > \text{var}(\ln F_{em}^a) \quad (20)$$

$$\text{var}(\ln Y_{em}) > \text{var}(\ln Y_{em}^a) \quad (21)$$

2. *If the variance of liquidity supply is sufficiently large compared to the variance of relative TFP, financial integration decreases the volatility of funding and the volatility of output in developed markets:*

$$\text{var}(\ln F_d) < \text{var}(\ln F_d^a) \quad (22)$$

$$\text{var}(\ln Y_d) < \text{var}(\ln Y_d^a) \quad (23)$$

These results provide some insight into the distinct behavior of emerging and developed markets following globalization. The theory above suggests that the

divergence in liquidity-driven output fluctuations may have been a result of developed markets effectively exporting their liquidity shocks to emerging markets.

## 5.2 Small open economies

Given that much of the literature on the excess volatility of emerging markets has focused on small open economies, it is useful to study small open economies in the context of this global equilibrium environment.

I assume that each region is composed of a continuum of small open economies, identical within regions. Small open economies are subject to idiosyncratic productivity shocks, as well as to exogenous shocks to  $r$  which result from changes in the global liquidity supply.

The first thing to note is that this model naturally implies comovements in emerging market economies. Compared to their developed counterparts, small open emerging markets are more severely affected by shocks to the global liquidity supply. The importance of global liquidity supply as a source of emerging market fluctuations naturally implies common movements in emerging market output levels. Similar to Fostel and Geanakoplos [2008], comovements in emerging market economies result from a common sensitivity to an external supply of funding.

Second, it is interesting to note that both in emerging and in developed markets, funding responds similarly to idiosyncratic productivity shocks and to shocks to the price of liquidity. This suggests a link between the heightened sensitivity of emerging markets to interest rate shocks (as in Neumeyer and Perri [2005] and Uribe and Yue [2006]) and the amplification of shocks to productivity (as in Caballero et al. [2005]). To see this link, note that in a small open economy, the level of funding is pinned down by a single indifference condition, equating the marginal product of funding with the world rate of return:

$$A_i y_i(F) = r \Rightarrow y_i(F) = \frac{r}{A_i} \quad (24)$$

From the formulation above, it is easy to see that funding is affected similarly by shocks to  $r$  and shocks to  $A_i$ . Essentially, in this model, the responsiveness of funding to either type of shock captures the density of projects which are implemented at the margin and collectively yield a return equal exactly to  $r$ . A

small shock to the returns of these projects will shift them above or below the implementation threshold; similarly, small shocks to  $r$  will determine whether or not the projects at the margin generate a return which justifies implementation. The result that small open emerging markets are relatively more sensitive to both shocks is closely tied to Property 1, as it guarantees that the density of projects implemented at the margin is higher.

The model presented in this section suggests the following conclusions regarding the role of financial institutions in determining the effects of financial integration on output volatility. Poor financial institutions in emerging markets exacerbate their sensitivity to funding, as well as increase the volatility of funding supplied to them. At times in which financial institutions are intact in developed markets, their superior ability to implement projects differentially serves both to stabilize equilibrium funding levels and to mitigate the effects of fluctuations in funding on output.

## 6 The endogenous deterioration of the financial system

In section 5 it was assumed throughout that the quality of financial institutions remains fixed upon financial integration. While this may be a valid short-run assumption, the recent subprime crisis comes as a reminder that the quality of financial institutions may evolve with changing circumstances.

In section 6.1 I consider a model in which the financial system in the developed world deteriorates endogenously following financial integration. In section 6.2 I discuss the implications of the deterioration during “normal times”. I show that in the absence of large shocks, the deterioration of the financial system actually increases and stabilizes output in the developed world. In section 6.3 I show that the deterioration in the financial system amplifies large adverse shocks.

## 6.1 Endogenous deterioration

I extend the setup to allow for an endogenous adjustment in the quality of the financial system in the developed world. Banks can choose the level of financial distortions out of some finite set. There is a cost  $\lambda(\phi)$  associated with choosing the level of distortions  $\phi$ , where  $\lambda(\cdot)$  is decreasing. This cost should be thought of as the cost of sorting projects and overcoming other obstacles which stand in the way of an efficient allocation. For simplicity, I assume that banks consider only the mean price of liquidity when choosing the level of financial distortions, and do not take into account any uncertainty.

Given a price of liquidity  $r$ , the banks choose the level of funding,  $F_d$ , and the level of distortion,  $\phi_d$ , to maximize profits. The bank's profits are given by:

$$\pi(r) = \max_{\phi_d, F_d} \{ \pi(r, F_d, \phi_d) \} = \quad (25)$$

$$\max_{\phi_d, F_d} \int_0^{F_d} y(F', \phi_d) dF' - rF_d - \lambda(\phi_d) \quad (26)$$

The following proposition characterizes the equilibrium response of the financial system to a global environment with the following two features: first, liquidity supply is high. The role of this assumption can be understood as follows. At low levels of funding, there is little incentive to invest in creating an efficient matching, as the scale of activity does not justify the cost. A marginal increase in funds will work towards countering this effect: the benefits of an efficient matching increase as there is more funding to be allocated efficiently. At some point, as we increase the level of funding, this type of scale effect works in the opposite direction: the returns to knowing which projects to exclude go down, as there are less projects to be excluded. The assumption that liquidity supply is sufficiently high restricts attention to this region.

The second feature of the global equilibrium environment is that  $\frac{A_d}{A_{em}}$  is relatively large. Note that  $\frac{A_d}{A_{em}}$  captures the relative returns generated by the same project in developed and emerging economies. The presence of limited enforcement in emerging economies would tend to imply a positive wedge between the productivity of a project and its return to investors. The role of the assumption that  $\frac{A_d}{A_{em}}$  is large is to generate a flow of funds from emerging to developed economies,

broadly consistent with the view of global imbalances expressed in Caballero et al. [2008].

**Proposition 4** *For  $Q_w$  and  $\frac{A_d}{A_{em}}$  sufficiently large, financial integration leads to an endogenous deterioration of the financial system in the developed market region.*

It is straightforward to show that the objective of banks in this model coincides with the objective of a social planner trying to maximize domestic output minus the costs of differentiation (taking  $r$  as given). The deterioration in the financial system can therefore be interpreted more broadly as an outcome of *endogenous* lax regulation.

In the context of the recent crisis, the above proposition formalizes the popular claim according to which financial integration increased the equilibrium level of financial distortions by lowering the price of liquidity from the developed market's perspective<sup>9</sup>. Intuitively, if liquidity is sufficiently cheap so that nearly all projects are implemented anyway, the benefits of differentiating between projects may not be worth the cost. Broadly interpreted, the financial system will gravitate towards various institutional arrangements that tie the implementation of high quality projects with the implementation of low quality projects.

## 6.2 Normal fluctuations

What are the implications of the deterioration of the financial system on output and on output volatility? Under autarky, the implications would be fairly intuitive: a weakening of the financial system would decrease output and increase subsequent output volatility<sup>10</sup>. However, these intuitive results breakdown under financial integration. The following proposition states that the deterioration in the quality

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<sup>9</sup>A note is in order regarding the applicability of these results to emerging market economies. The analysis in this section relies heavily on the assumption that financial integration is associated with a decline in the price of liquidity from the domestic perspective. The results are therefore not applicable for emerging markets. For emerging markets, the mirror image is the relevant one: financial integration is associated with an increase in  $r$ , potentially leading to an endogenous increase in the quality of financial institutions. The characterization of the long run general equilibrium environment, in which financial institutions are allowed to adjust in both emerging and developed economies, is beyond the scope of this paper. I leave this interesting issue for future research.

<sup>10</sup>To see this, note that by Lemma 7 in the Appendix, holding funding fixed, output is higher when financial institutions are intact (because a superior set of projects are implemented). Thus,



of the financial system in the developed world will increase funding in that region, and may increase and stabilize output as well:

**Proposition 5** *An endogenous weakening of the financial system in the developed market will:*

1. *Increase the flow of funds from emerging to developed economies.*
2. *If the increase in flows is sufficiently large (which will be the case for a sufficiently large  $\frac{A_d}{A_{em}}$ ), developed market output will increase and stabilize conditional on small fluctuations.*

Abandoning the higher standard of differentiation causes inefficient projects that were implemented at the margin to be implemented inframarginally, while more productive projects become marginal. This lowers the average return to funding, but increases the *marginal* return to funding. In the integrated equilibrium, this increase in domestic marginal returns leads to additional inflows of funding. If these flows are sufficiently large, domestic output will rise.

The increase in the marginal return also serves to stabilize output, as domestic funding adjusts less to fluctuations in the interest rate. Intuitively, when the domestic marginal return is higher, a larger fraction of the economy becomes globally inframarginal. Of course, section 4 illustrates that the economy becomes more sensitive to fluctuations in domestic funding: so, while  $F$  becomes less volatile, the economy becomes more sensitive to fluctuations in  $F$ . Conditional on small global fluctuations, the first effect dominates and volatility declines.

Proposition 5 can shed light on the seemingly “irrational” behavior that led up to the subprime crisis, in which many bad loans were given to subprime borrowers, and, while the financial system behaved “irresponsibly”, the demand for US assets seemed only to increase. This result suggests that this type of indiscriminate lending raised the expected marginal return to funds in the US, leading to additional inflows.

Finally, does the fact that output in the developed world increases with the deterioration of its financial system mean that such a deterioration is “good”?

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a weakening of the financial system constitutes an adverse shock to output. The fact that subsequent output volatility increases is immediate from the comparison between closed emerging and developed economies in section 4.

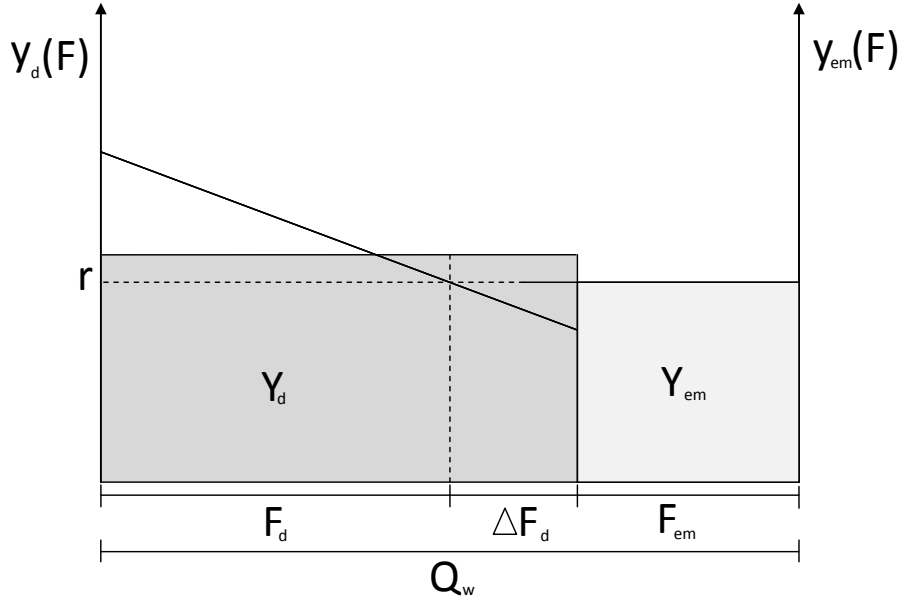


Figure 4: The origin of the developed economy is on the left corner, and the origin of the emerging economy is on the right corner. The market clearing condition states that the distance between the two corners is equal to the global liquidity supply,  $Q_w$ . The intersection of the marginal products of funding determines  $r$ . A deterioration of the financial system in the developed world causes funding to flow towards that region. In this figure, the deterioration of the financial system is illustrated by the “flattening” of the marginal return to funding. The size of the increase in  $F_d$  is given by  $\Delta F_d$ , the distance between the intersection of the autarkic (sloping) marginal return to funding and  $r$ , and the point of satiation ( $F_d = 1$ ).

From a global perspective, no. The generic adverse effect of a deterioration in the financial system is that it decreases world output, both under autarky and under financial integration:

**Lemma 1** *A weakening of the financial system in the developed world decreases world output.*

This lemma is immediate from the fact that intact financial institutions allow for a differential implementation of projects based on their returns; the set of projects implemented when differentiation is not possible is necessarily inferior to the set of projects implemented when some differentiation is possible.

### 6.3 Large adverse shocks

In the global environment described in this paper, the deterioration of the financial system in the developed world serves to increase and stabilize output in that region during normal times. However, while the response to small shocks is mitigated, the output response to large negative shocks is amplified:

**Proposition 6** *In the developed world, the weakening of the financial system amplifies the output response to large adverse shocks to  $Q_w$  or  $\frac{A_d}{A_{em}}$ .*

Intuitively, cheap liquidity leads to structural changes in the financial system that disable the separation of high-quality projects from low-quality projects. During normal times, this increases the amount of low-quality projects being implemented, and output increases as a result. However, sufficiently large contractions in liquidity are amplified by the inability to separate the discontinuation of low-quality projects from the discontinuation of high-quality projects.

This result suggests that the deterioration in the quality of financial institutions preceding the sub-prime crisis may have indeed precipitated it by creating an amplification mechanism for large adverse shocks. This amplification mechanism is consistent with many inefficiencies that seem important for understanding the extent of the crisis. A straightforward interpretation is the mortgage market itself. The creation of mortgage backed securities enabled the pooling of idiosyncratic risk of subprime loans. Once housing prices declined, issuing new subprime loans

became difficult, perhaps in part because the process of issuing subprime loans did not allow for differentiation between relatively promising borrowers and relatively unpromising borrowers. A more subtle interpretation is in balance sheet effects (as in Brunnermeier [2009]). The heavy reliance of banks' balance sheets on mortgage backed securities forced them to disengage from productive lending activities once the subprime crisis hit. This can be viewed as an additional mechanism that ties the implementation of productive projects to the implementation of unproductive projects.

**Corollary 1** *Financial integration may lead to the amplification of large adverse shocks in the developed world.*

Corollary 1 is immediate from the analysis in this section: by Proposition 4, financial integration leads to the deterioration of the financial system. By Proposition 6, the deterioration in the financial system amplifies the output response to large adverse shocks.

Note that this analysis also suggests that the subprime crisis cannot be explained solely in terms of a breakdown in the financial system; rather, a complete explanation would require either an additional large shock to TFP or to liquidity supply.

The results in this section present a modification to the view presented in section 5 according to which financial integration mitigates output fluctuations in the developed world. If financial integration with a distorted emerging market region is coupled with a decline in the price of liquidity, financial institutions may deteriorate in accordance with Proposition 4. As a result, the sensitivity of output with respect to small shocks will decline, but large adverse shocks will be amplified.

## 7 The financial system as a matching mechanism

The results presented in the previous sections rely heavily on Property 1. In this section, I derive Property 1 from two primitive assumptions on the effect of financial distortions on the matching between funding priorities and projects. I present empirical evidence for these assumptions, and show that Property 1 can be derived from a variety of microfoundations.

Before proceeding to the general case, it is useful to consider the following simplified example. Assume that there are only two funding priorities, “high” and “low”, and only two types of projects, “good” and “bad”. The good project produces 3 if implemented, and the bad project only produces 1 if implemented ( $g(\text{good}) = 3$  and  $g(\text{bad}) = 1$ ; for simplicity, I’ve assumed  $A = 1$ ).

In an efficient economy, the good project would be prioritized higher than the bad project. However, in a distorted economy, there may be frictions that prevent the efficient matching between funding priorities and projects: with some probability  $\phi$ , the bad project will be prioritized higher than the good project:

$$\sigma_\phi(\text{bad project, high priority}) = \phi$$

$$\sigma_\phi(\text{bad project, low priority}) = 1 - \phi$$

$$\sigma_\phi(\text{good project, high priority}) = 1 - \phi$$

$$\sigma_\phi(\text{good project, low priority}) = \phi$$

Note that  $\phi = 0$  corresponds to the efficient case; a higher  $\phi$  corresponds to a more distorted economy, in which the probability of implementing the bad project before the good project is higher. Given  $\phi$ , the marginal return to the first unit of funding is equal to the expected productivity of the project that receives the high funding priority:

$$y(\text{first unit of funding}) = (1 - \phi) \cdot 3 + \phi \cdot 1 = 3 - 2\phi \quad (27)$$

The marginal return to the second unit of funding is the expected productivity of the project that receives a low funding priority:

$$y(\text{second unit of funding}) = (1 - \phi) \cdot 1 + \phi \cdot 3 = 1 + 2\phi \quad (28)$$

The ratio of the marginal return to the second unit of funding and the marginal return to the first unit of funding is therefore increasing in  $\phi$ , in accordance with

the log supermodularity condition in Property 1:

$$\frac{y(\text{second unit of funding})}{y(\text{first unit of funding})} = \frac{1 + 2\phi}{3 - 2\phi} \quad (29)$$

Note that the log supermodularity condition holds both because the return to the second unit funding is increasing in  $\phi$ , and because the return to the first unit of funding is decreasing in  $\phi$ . In other words, the ratio of the marginal returns increases with  $\phi$  both because good projects are more likely to receive a low priority, and because bad projects are more likely to receive a high priority.

For the general case, I am going to present two assumptions on the set of matching functions  $\{\sigma_\phi\}_{\phi \in \Phi}$  that loosely correspond to these conditions, which guarantee that the resulting marginal return to funding is log supermodular, consistent with Property 1.

For this purpose, it is convenient to fix two funding priorities,  $p'$  and  $p \geq p'$ , and two levels of distortions,  $\phi'$  and  $\phi \geq \phi'$ . We will be interested in comparing the two matching functions ( $\sigma_\phi$  and  $\sigma_{\phi'}$ ) in terms of the relative likelihood that projects of certain types are assigned funding priorities  $p$  and  $p'$ . Given the choices of  $p$ ,  $p'$ ,  $\phi$ , and  $\phi'$ , for a measurable subset  $X$ , let  $D(X)$  be a given by:

$$D(X) = \int_X \sigma_\phi(x, p) dx \int_X \sigma_{\phi'}(x, p') dx - \int_X \sigma_\phi(x, p') dx \int_X \sigma_{\phi'}(x, p) dx \quad (30)$$

The measure  $D(X)$  compares  $\phi$  and  $\phi'$  in terms of the relative likelihood that projects of types  $x \in X$  receive higher funding priority. To develop intuition, consider for example the statement  $D(X) < 0$ . Assuming that all measures are strictly positive, this statement holds true if and only if:

$$D(X) < 0 \Leftrightarrow \frac{\int_X \sigma_{\phi'}(x, p') dx}{\int_X \sigma_{\phi'}(x, p) dx} < \frac{\int_X \sigma_\phi(x, p') dx}{\int_X \sigma_\phi(x, p) dx} \quad (31)$$

In words, this means that the ratio of the likelihood that projects of types  $x \in X$  receive priority  $p'$  (a high priority) and the likelihood that they receive priority  $p$  (a low priority) is relatively smaller in less distorted economies. This statement seems reasonable for  $X$  that is composed of relatively “bad” projects: in an efficient economy, these projects are unlikely to receive a high funding priority. In a distorted economy, this type of mistake can happen sometimes.

The above suggests that a reasonable assumption is that  $D(X) < 0$  for a set  $X$  that is composed of “bad” projects. Similarly, it is reasonable to assume that for a set  $X$  composed of “good” projects,  $D(X) > 0$ :

$$D(X) > 0 \Leftrightarrow \frac{\int_X \sigma_{\phi'}(x, p') dx}{\int_X \sigma_{\phi'}(x, p) dx} > \frac{\int_X \sigma_{\phi}(x, p') dx}{\int_X \sigma_{\phi}(x, p) dx} \quad (32)$$

In words, good projects are relatively *more* likely to receive higher priority in less distorted economies.

But what is a set of “good” projects? Given the restriction to a decreasing  $g(\cdot)$ , we know that projects of types  $x \in [0, \bar{x}]$  are relatively better than projects of types  $x \in [\bar{x}, 1]$ . A set of the form  $X = [0, \bar{x}]$  is therefore a set of relatively good projects. The first assumption is as follows:

**Assumption 1** *Let  $X$  be of the form  $X = [0, \bar{x}]$ . Then,  $D(x) \geq 0$ .*

For the purpose of the second assumption, it is convenient to impose a partial ordering on the set of subsets of the form  $X = [\underline{x}, \bar{x}]$ : it will be said that  $X > X'$  if all elements in  $X$  are larger than all elements in  $X'$  ( $\underline{x} \geq \bar{x}'$ ).

**Assumption 2** *For every two segments  $X'$  and  $X > X'$ ,  $D(X') \geq D(X)$ .*

This assumption loosely implies that relatively better projects are relatively more likely to receive higher funding priority in less distorted economies. As we’ve seen above, for  $X$  composed of “bad” projects, we are likely to see  $D(X) < 0$ , whereas for  $X$  composed of “good” projects, we are likely to see  $D(X) > 0$ . This assumption essentially states that  $D(X)$  is monotone; if all projects  $x' \in X'$  are better than all projects  $x \in X$ , then  $D(X') \geq D(X)$ .

**Theorem 1** *Assumptions 1 and 2 imply compliance with Property 1 for any positive and decreasing  $g(\cdot)$ .*

Assumptions 1 and 2 essentially state that distortions make it less likely for good projects to be matched with high funding priorities, and that as we decrease the quality of projects they become relatively more likely to be prioritized higher in more distorted economies. The theorem then states that when funding

priorities are distorted in this fashion, the average quality of projects with high funding priorities is relatively closer to the average quality of projects with low funding priorities. As the aggregate marginal return to funds is equal to the average productivity of projects with marginal funding priority (equation 2), this implies compliance with Property 1.

## 7.1 Empirical interpretation

How plausible are Assumptions 1 and 2? In this section I present empirical evidence that is consistent with Assumptions 1 and 2, and is hence supportive of Property 1 (by Theorem 1) .

As illustrated in the previous sections, there are many general equilibrium implications of Property 1 that are consistent with empirical regularities. However, there are obvious problems with testing Property 1 directly. Essentially, it would require an exogenous source of variation in the supply of funding that does not also affect the productivity of funding. This is problematic, as we would expect that periods of high productivity would imply both that the returns to funding are higher and that the supply of funding is larger. Using the standard small open economy trick and restricting attention on global variation in the supply of funding is not helpful here, as it may capture variation in global productivity that also affects the domestic marginal return to funds.

Appendix A presents an empirical investigation of Assumptions 1 and 2. I use the AMADEUS data set<sup>11</sup>, that includes balance sheet data for all formal sector firms for several European and Eastern European countries, between the years 1990-2011. For each firm, I construct a measure of the marginal productivity of funding ( $A_i$ ). In the appendix I illustrate how this measure maps into the productivity of projects ( $Ag(x)$ ).

I divide the set of countries into “distorted” and “efficient” based on the crude measure of GDP per capita. I choose the cutoff to be the GDP per capita in Cyprus. After removing countries with insufficient data, the list of “efficient” economies includes Austria, Belgium, Finland, France, Germany, Iceland, Italy, Luxembourg, Netherlands, Norway, Spain, Sweden and Switzerland. The list of “distorted”

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<sup>11</sup>The AMADEUS database (Analyze Major Databases from European Sources) is published by Bureau van Dijk Electronic Publishing.



economies includes Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Moldova, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia and the Ukraine.

**Testing Assumption 1.** Assumption 1 states that in less distorted economies, productive projects are more likely to receive higher funding priorities. Of course, funding priorities are not observable so this assumption cannot be tested directly. However, we can get a crude measure of funding priority by calculating the extent to which the implementation of the project depends on the aggregate supply of funding. If a project has high priority, its implementation will depend little on the aggregate supply of funds. Projects with lower funding priorities will be more vulnerable to shocks to the aggregate supply of funds (unless of course they are not implemented at all; these projects, however, will not show up in the data).

I test whether in less distorted economies, relatively more productive projects are less sensitive to fluctuations in the aggregate supply of funds. For each country, I divide the set of projects in each year into “high productivity” and “low productivity” projects, depending on whether their productivity is in the top  $k$  percentile. Denote the set of high productivity projects by  $X(k)$ .

I regress the funding of firm  $i$  on aggregate funding, adding an interaction term for productive projects. I then test whether the coefficient on the interaction term is smaller for less distorted economies, that is, for efficient economies the implementation of productive projects depends less on the aggregate supply of funds. I consider the following specification:

$$F_i = \beta_{agg} F_{agg} + \beta_{high,k}(F_{agg} \cdot \chi\{i \in X(k)\}) \quad (33)$$

I then calibrate the empirical counterpart of  $D(X(k))$  as:

$$\hat{D}(X(k)) = -\beta_{high,k}^{efficient} - (-\beta_{high,k}^{distorted}) = \beta_{high,k}^{distorted} - \beta_{high,k}^{efficient} \quad (34)$$

Where the superscripts indicate the coefficients estimated on the efficient and distorted subsamples. I then test the hypothesis  $\hat{D}(X(k)) \geq 0$ .

I do this exercise for  $k = 25\%$ ,  $k = 50\%$ , and  $k = 75\%$ . In all three cases, I find support for the hypothesis (at least at the 5% confidence level). The results

are summarized in figure 5.

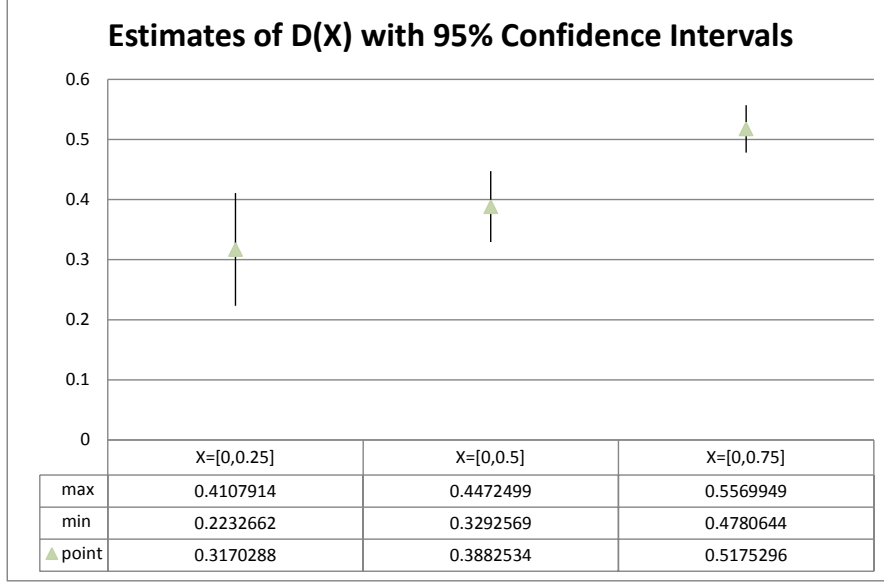


Figure 5: The estimated values of  $D(X(k))$ . The figure illustrates that the data is consistent with the assumption that  $D(X) \geq 0$  for all  $X$  of the form  $X = [0, \bar{x}]$ . 24,026,371 observations; standard errors adjusted for 392 clusters representing country-year pairs.

**Testing Assumption 2.** Assumption 2 loosely states that relatively better projects are relatively more likely to receive high funding priority in more efficient economies. In similar spirit, I divide the projects in each country and each year into 4 (disjoint) groups based on the quartile of their productivity. The quartiles correspond to the sets of projects  $X_1 = [0, 0.25]$ ,  $X_2 = [0.25, 0.5]$ ,  $X_3 = [0.5, 0.75]$  and  $X_4 = [0.75, 1]$ .

For each quartile  $q = 1, \dots, 4$ , I run the following regression:

$$F_i = \beta_{agg} F_{agg} + \beta_q (F_{agg} \cdot \chi\{i \in X_q\}) \quad (35)$$

Similarly, the empirical counterpart of  $D(X_q)$  is given by:

$$\hat{D}(X_q) = \beta_q^{distorted} - \beta_q^{efficient} \quad (36)$$

Assumption 2 would suggest that for  $X' < X$  (or  $q' < q$ ),

$$\hat{D}(X') \geq \hat{D}(X) \quad (37)$$

The results are summarized in figure 6. Consistent with the hypothesis, the estimates  $\hat{D}(X_q)$  are weakly monotone in the sense that for  $q' < q$ , the 95% confidence interval of  $\hat{D}(X_{q'})$  either overlaps with the 95% confidence interval of  $\hat{D}(X_q)$  or is strictly above it. As we would expect, the estimate is positive for the first quartile but negative for the last quartile.

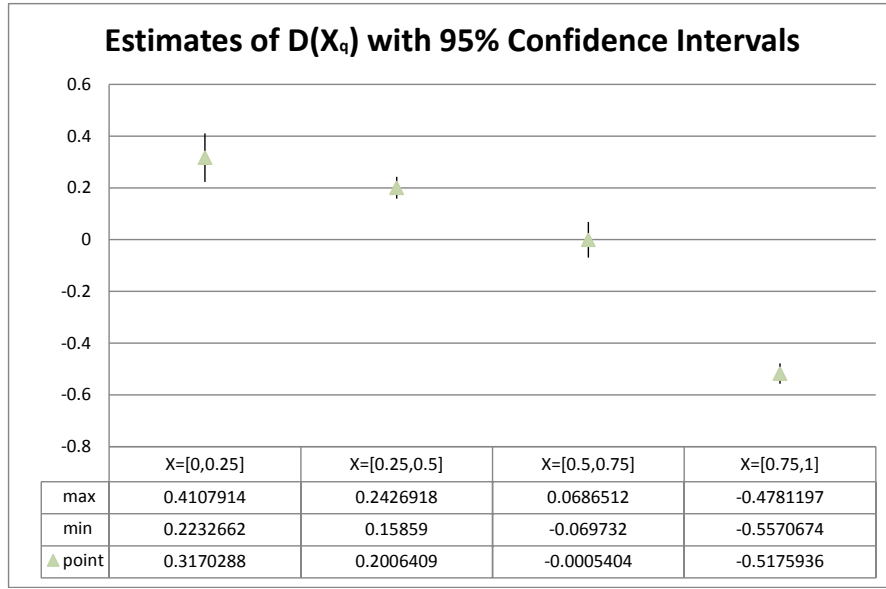


Figure 6: The estimated values of  $D(X_q)$ . The figure illustrates that the data is consistent with  $D(X_q)$  being weakly monotone decreasing in  $q$ . 24,026,371 observations; standard errors adjusted for 392 clusters representing country-year pairs.

## 7.2 Microfoundations

In this section I present different microfoundations of distortions that comply with Property 1. These microfoundations are intended to illustrate both the plausibility of compliance with Property 1, and the flexibility that Property 1 allows in specifying the sources of distortions.

**Incomplete information.** Projects' types are unobservable; instead, implementation decisions are made based on a signal that is correlated with the project's quality,  $s(x)$ . There are two signals: half the projects receive the signal  $G$  ("good") and the other half receive the signal  $B$  ("bad"). The average quality of projects receiving the signal  $G$  is higher than the average quality of the projects receiving the signal  $B$ ; thus, all projects with  $G$  signals will be implemented before any projects with  $B$  signals will be implemented.

The parameter  $\phi$  governs the noisiness of the signal. If  $\phi' \leq \phi$ , the signal  $\phi'$  is more informative in the sense that for every  $\bar{x}$ :

$$Pr_{\phi'}(x \leq \bar{x} | s(x) = G) \geq Pr_{\phi}(x \leq \bar{x} | s(x) = G) \quad (38)$$

$$Pr_{\phi'}(x \leq \bar{x} | s(x) = B) \leq Pr_{\phi}(x \leq \bar{x} | s(x) = B) \quad (39)$$

In other words, the distribution of projects that receive a good signal under  $\phi'$  stochastically dominates the distribution of projects that receive a good signal under  $\phi$ ; the distribution of projects that receive a bad signal under  $\phi$  stochastically dominates the distribution of projects that receive a bad signal under  $\phi'$ .

**Lemma 2** *In this model of incomplete information, Assumptions 1 and 2 are satisfied. Hence, Property 1 is satisfied for any  $g(\cdot)$ .*

**Government intervention.** The government owns a fraction  $\phi$  of the economy: a fraction  $\phi$  of each project is owned by the government, and the government controls a fraction  $\phi$  of the funds. The government distributes its funds among government-owned projects; I assume that it does so inefficiently, and that the likelihood that a project receives government funding is uncorrelated with its productivity.

The private sector efficiently distributes its funds among privately-owned projects, financing the more productive projects before allocating funds to the less productive projects. The matching function  $\sigma_{\phi}(\cdot, \cdot)$  therefore satisfies:

$$\int_0^x \sigma_{\phi}(z, F) dz = (1 - \phi) \int_0^x \sigma_{eff}(z, F) dz + \phi x \quad (40)$$

Where  $\sigma_{eff}(\cdot, \cdot)$  is defined by equation 4. Here, the value of  $\phi$  determines the

level of distortion: a higher  $\phi$  implies that the government runs a larger part of the economy, so more funds are being allocated randomly.

**Lemma 3** *In this model of government intervention, Assumptions 1 and 2 are satisfied. Hence, Property 1 is satisfied for any  $g(\cdot)$ .*

**Collateral constraints.** Consider a model in which projects are characterized by their type,  $x$ , and by their collateral type,  $b$ . Assume that collateral types ( $b$ ) are distributed independently from the project type ( $x$ ). Conditional on any project type, collateral is uniformly distributed on  $[0, \phi]$ . The collateral level of the project is given by the following decreasing function:

$$\kappa(b) = g(\min\{b, 1\}) \quad (41)$$

That is, collateral is decreasing in  $b$ , and is bounded from below by the productivity of the least productive project.

A project with features  $(x, b)$  is implemented if and only if both its return and its collateral level exceed the price of funding:

$$g(x) \geq r \quad (42)$$

$$\kappa(b) \geq r \quad (43)$$

The mismatch between the quality of projects and their collateral changes the order in which projects are implemented. Note that a higher  $\phi$  implies that the aggregate collateral is lower. It is easy to see that  $\phi \rightarrow 0$  corresponds to the efficient allocation, as all projects have sufficient collateral to be implemented when their return is high enough. The case  $\phi \rightarrow \infty$  corresponds to an extremely distorted economy, in which essentially all projects are collateral constrained and can be implemented only when the market return is equal to the productivity of the least productive project; in this case, the marginal product of funding is close to constant, as projects are implemented essentially in a random order (as in the previous example).

**Lemma 4** *Assume that  $g(x) = \alpha x^{-(1-\alpha)}$ . In this model of collateral constraints, Property 1 is satisfied.*

Note that in this model, Property 1 is guaranteed only for the given functional form of  $g(\cdot)$ . I leave the question of generality for future exploration.

**Search frictions.** Consider a model in which economies differ in the search technology available to their banks. In each economy there are  $\phi$  local banks indexed  $i = 0, \dots, \phi - 1$ . Projects owners are unaware of their project's type until right before production decisions must be made. Local banks are modeled as risk sharing arrangements among project owners. Each local bank shares risk among  $\frac{1}{\phi}$  project owners. The bank indexed  $i$  is a risk sharing arrangement between the owners of projects indexed  $x \in (\frac{i}{\phi}, \frac{i+1}{\phi}]$  (for  $i = 0$ , the segment of projects is the closed set  $[0, \frac{1}{\phi}]$ ). The process of distributing funds from households to projects is as follows:

1. Households supply funds to a large savings bank. The savings bank has direct access to projects (but is unaffiliated with the local banks, and is unaware of projects' types).
2. The savings bank distributes funds randomly among projects owners.
3. Project owners handover their funds to their local bank. When the productivity of projects is revealed, the local bank uses the funds in its hands to implement the best set of projects among those owned by the bank's members.

The parameter  $\phi$  can be thought of as a measure inversely related to the integration of the domestic financial system. A high  $\phi$  captures a situation in which there are some banks with access to highly productive projects that lack liquidity to implement them, and some banks with high liquidity without access to good projects. The case  $\phi = 1$  corresponds to the efficient allocation: there is only one bank in charge of allocating the entire supply of funds, and the bank has access to the entire set of projects. The optimal set of projects is therefore implemented. The case  $\phi \rightarrow \infty$  corresponds to the random allocation example: project owners are essentially in autarky, as they must use their own funds to implement their own project. The implementation of projects is therefore random, as it does not depend on the level of productivity.

**Lemma 5** *Assume that  $g(x) = e^{-x}$ . In this model of search frictions, Property 1 is satisfied.*

Similar to the model of collateral constraints, Property 1 is guaranteed only for a given functional form of  $g(\cdot)$ . Similarly, I leave the question of generality for future exploration.

## 8 Conclusion

This paper studies the effects of financial distortions on the global equilibrium environment. I present a reduced form formulation of financial distortions according to which the marginal return to funding is log supermodular in funding and the level of distortion. This formulation is consistent with a class of microfoundations in which the distortion creates a mismatch between projects and funding priorities, in a way which results in an order of implementation which is less indicative of the relative quality of projects.

Upon financial integration, financial distortions affect global volatility patterns through two related channels: first, financial distortions determine the sensitivity of output to liquidity supply. Output in emerging markets is more sensitive to liquidity supply, because the projects implemented at the margin have high returns compared to the projects implemented infra-marginally. Second, in the integrated economy, the higher level of distortion in emerging markets causes them to absorb a larger fraction of the volatility of global liquidity supply. As a result, financial integration increases liquidity-driven output volatility in emerging markets, and decreases liquidity-driven output volatility in developed markets.

In the long run, a global environment in which liquidity is cheap is conducive to a deterioration in the financial system in the developed world. In the integrated economy, a deterioration in the quality of the financial system has a mixed effect on output in developed economies: in the absence of large liquidity or TFP shocks, it serves to increase output and to reduce output volatility. However, the response of output to large adverse liquidity shocks is amplified. This offers a modified view regarding the long run effect of financial integration on developed market output volatility. As the quality of financial institutions adjusts downward, the economy

becomes less sensitive to normal fluctuations, but more adversely affected by large shocks.

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## A An empirical interpretation of Assumptions 1 and 2

Let firms be indexed by  $i \in I$ . A subscript  $i$  indicates a variable belonging to firm  $i$ , that is,  $F_i$  is the funding allocated to firm  $i$ ,  $A_i$  is the productivity of firm  $i$ , etc. Variables common to all firms within a country in a given year will be denoted with a subscript *agg*. Country variables are denoted with subscript  $j$ .

**Estimating  $F_i$ .** I interpret  $F$  to be the cost of production. I estimate it as the maximum of the firm's reported cost and its reported expenses on materials and labor.

Why should  $F$  be interpreted as the entire cost of production, and not only the part of it paid in advance of production? In a broad sense, all inputs must be paid in advance of production, either with a claim on future consumption backed by the government (money) or a claim on future consumption backed by some other agent in the economy (for example producer or bank credit). The distinction is immaterial for our purposes, especially as the recent crisis suggests that much of the variation in the ability to employ inputs is a result of variation in the ability of non-government entities to generate promises for future repayment.<sup>12</sup> Appendix C further develops the idea that shocks to the private sector's ability to issue promises for future repayment is similar to a shock to the money supply.

I deflate  $F_i$  by the GDP deflator and subtract the output trend (calculated from the IMF's IFS database). The decision to subtract the output trend is motivated by the idea that the trend in productivity translates into a trend costs, which is a result in most standard models. I also allow for a country specific time trend in  $F_i$  to account for any other unobservable trends.

**Estimating  $A_i$ .** I assume that firms have constant returns to funding. This is consistent with any standard Cobb-Douglas production function, where funding reflects the cost of labor and capital (note that this assumption is consistent with

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<sup>12</sup>There are also technical issues in identifying the component of inputs that must be paid in advance. The common practice of using working capital is lacking, as this assumes away both other uses of cash and other sources of cash that can be used to purchase inputs.

different firms having different capital and labor intensities, as long as constant returns to scale is satisfied).

Given this assumption, the marginal product of funding (MPF) is given by the ratio of output to funding:

$$Y_i = A_i F_i \Rightarrow A_i = \frac{Y_i}{F_i} \quad (44)$$

I use sales data as the empirical counterpart of  $Y$ <sup>13</sup>.

Mapping this measure of  $A_i$  into our model requires some structure. I augment the model to allow for firms. I assume that there is a measurable set  $i \in I$  of firms, and that each firm  $i$  owns a discrete collection of projects  $x_i \in X_i$ , where it is assumed that for any  $x_i \in X_i$ :

$$Ag(x_i) = A_i \quad (45)$$

I assume that every firm can expand, that is, no firm has all projects implemented in full; all producing firms are responsive to some degree to aggregate fluctuations.

I assume that the sample distribution of  $x_i$  is similar across countries. This assumption is obviously not realistic: we would expect that in more distorted economies, the marginal productivity of producing firms would be more dispersed as in Hsieh and Klenow [2009]. However, this would create a bias against the results: for example, if the top 25% of marginal projects in distorted economies are (relatively) more productive than the top 25% of marginal projects in developed economies, the fact that they are relatively more responsive to aggregate fluctuations is even more striking (as efficiency would dictate that these projects should be even more inframarginal on average). For notational convenience, I assume that the set of marginal projects is randomly distributed on  $[0, 1]$  - that is, I label the top 25% of marginal projects  $X = [0, 0.25]$ .

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<sup>13</sup>Of course, there are problems with this measure as it abstracts from investment in inventory; I am thus assuming that the share of investment in inventory is independent of productivity. Ignoring investment in inventory does not bias the result as long as sales and productivity remain positively correlated (within the same country and the same year).

**Estimating  $F_{agg}$ .** A naive way of estimating  $F_{agg}$  would be to sum up the amount of funding of all firms in a given country-year pair. However, this is problematic as, after being cleaned, the data accounts only for a fraction of all production. Further, this fraction fluctuates considerably across years, as evident from the large variation in observations across time. To account for this, I create a sampling constant that represents the fraction of output produced by firms in the dataset, assuming that firms are sampled randomly. I calculate this sampling constant as the fraction of total sales in the sample divided by GDP in current prices<sup>14</sup>. I then calibrate the aggregate supply of  $F$  by summing up  $F_i$  and dividing by the sampling constant.

Of course, there is a concern that for some larger firms, this variable is endogenous as by construction it is highly correlated with  $F_i$ . I therefore remove any firm for which  $F_i > 0.01F_{agg}$ .

I drop all country-year pairs that have less than 40 observations.

**Testing Assumption 1.** Let  $\chi_e$  be a dummy variable indicating whether the firm belongs to an “efficient” economy (for a list of “efficient” and “distorted” economies, see the description in section 7.1).

For each country for each year, I create dummy variables indicating whether a firm is in the top  $k\%$  in terms of its productivity (relative to other firms in that country-year). I do this for  $k = 25$ ,  $k = 50$  and  $k = 75$ . Denote by  $\chi_k$  the corresponding dummies sets of productive projects.

Let  $c_j$  be country dummies and let  $t_j$  be time interacted with country dummies (to allow for country-specific trends in  $F_i$ ).

I run the following regressions:

$$\ln(F_i) = \beta_{agg} \ln(F_{agg}) + \beta_{agg}^{eff}(\ln(F_{agg}) \cdot \chi_e) + \beta_{agg,k}(\ln(F_{agg}) \cdot \chi_k) + \quad (46)$$

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<sup>14</sup>GDP data is taken from the IMF’s World Economic Outlook (WEO) database. Note that the underlying assumption in this calculation is that the ratio of aggregate sales to GDP is constant across time (within a country, up to a time trend). Recall that GDP is defined as the the total amount of *final* sales. Total sales differs from GDP in that it includes also sales of intermediate inputs. Unfortunately, as many countries do not have data on costs of intermediate inputs, it is impossible to construct a “sample GDP” by subtracting the costs of intermediate inputs from final sales. However the assumption that the ratio of sales to GDP is constant is reasonable if the chain of production does not fluctuate considerably across time.

$$\beta_{agg,k}^{eff}(\ln(F_{agg}) \cdot \chi_k \cdot \chi_e) + \sum_j \gamma_j c_j + \sum_j \delta_j t_j + const$$

I test whether  $\beta_{agg,h}^{eff} < 0$ . If so, this means that more productive projects are relatively less sensitive to aggregate fluctuations (i.e., implemented with higher priority) in efficient economies. To map this back to the model, we can write:

$$\hat{D}(\text{top } k\text{-th percentile}) = -\beta_{agg,k}^{eff} \quad (47)$$

The variable  $\hat{D}$  is a measure of how much more likely are the top  $k\%$  of projects to receive a higher funding priority in efficient economies, that is, be *less* sensitive to aggregate fluctuations.

The results of the regressions are summarized in figure 5.

**Testing Assumption 2.** In each country-year, I divide the set of firms into 4 disjoint groups based on their productivity quartile. Denote by  $\chi_q$  the indicator variable indicating whether the firm belongs to the  $q$ -th quartile (here  $q = 1$  is the top quartile and  $q = 4$  is the bottom quartile).

I run the following regressions:

$$\ln(F_i) = \beta_{agg} \ln(F_{agg}) + \beta_{agg}^{eff}(\ln(F_{agg}) \cdot \chi_e) + \beta_{agg,q}(\ln(F_{agg}) \cdot \chi_q) + \quad (48)$$

$$\beta_{agg,q}^{eff}(\ln(F_{agg}) \cdot \chi_q \cdot \chi_e) + \sum_j \gamma_j c_j + \sum_j \delta_j t_j + const$$

Similarly, we can define:

$$\hat{D}(q) = \hat{D}(q\text{-th quartile}) = -\beta_{agg,q}^{eff} \quad (49)$$

I test the hypothesis that the series  $\hat{D}(1), \hat{D}(2), \dots$  is weakly monotone decreasing. The results are summarized in figure 6. As illustrated by the figure, this hypothesis cannot be rejected at the 5% confidence level, as the confidence intervals of any consecutive  $-\beta_q$  are either overlapping or strictly decreasing. As evident from the figure, there is a clear downward trend in  $-\beta_q$ .

## B Proofs

### B.1 Proof of Proposition 1

To show that  $Y(F, \phi)$  is log supermodular, write  $Y(F, \phi)$  as:

$$Y(F, \phi) = \int_0^\infty 1_{[0, F]}(n) y(n, \phi) dn \quad (50)$$

Where  $1_{[0, F]}$  denotes the indicator function which takes a value 1 over the interval  $[0, F]$  (and 0 elsewhere).

Recall the definition of log supermodularity as it appears in Costinot [2009], which allows for 0 values:

**Definition 1** For  $X \subset \mathbb{R}^w$ , a function  $h : X \rightarrow \mathbb{R}^+$  is log supermodular if for all  $z, z' \in X$ ,

$$h(\max(z_1, z'_1), \dots, \max(z_m, z'_m)) h(\min(z_1, z'_1), \dots, \min(z_m, z'_m)) \geq h(z) h(z') \quad (51)$$

**Claim 1** The function  $h(F, n, \phi) = 1_{[0, F]}(n)$  is log supermodular in  $F$ ,  $n$ , and  $\phi$ .

To see this, note that both sides of the inequality in 51 can be either 0 or 1, and consider the case in which the left hand side of the inequality is 0:

$$h(\max(F, F'), \max(n, n'), \max(\phi, \phi')) h(\min(F, F'), \min(F, F'), \min(\phi, \phi')) = 0 \quad (52)$$

$$1_{[0, \max(F, F')]}(\max(n, n')) 1_{[0, \min(F, F')]}(\min(n, n')) = 0 \quad (53)$$

Assume without loss of generality that  $\max(n, n') = n$ . From the above equality,  $1_{[0, \max(F, F')]}(\max(n, n')) = 0$  or  $1_{[0, \min(F, F')]}(\min(n, n')) = 0$ . Assume  $1_{[0, \max(F, F')]}(\max(n, n')) = 0$ . Thus,

$$n > \max(F, F') \Rightarrow n > F \Rightarrow 1_{[0, F]}(n) = 0 \Rightarrow 1_{[0, F]}(n) 1_{[0, F']}(n') = 0 \quad (54)$$

Assume instead that  $1_{[0, \min(F, F')]}(\min(n, n')) = 0$ . There are two cases: if  $\min(F, F') = F'$ ,



$$n' > F' \Rightarrow 1_{[0,F']}(n') = 0 \Rightarrow 1_{[0,F]}(n)1_{[0,F']}(n') = 0 \quad (55)$$

if, instead,  $\min(F, F') = F$ , since  $\max(n, n') = n$ ,

$$n' > F \Rightarrow n > F \Rightarrow 1_{[0,F]}(n) = 0 \Rightarrow 1_{[0,F]}(n)1_{[0,F']}(n') = 0 \quad (56)$$

Thus, log supermodularity is satisfied.

The assumption that  $y(n, \phi)$  is log supermodular in  $(n, \phi)$  implies trivially that it is log supermodular as a function of  $(F, n, \phi)$ .

Since the product of two log supermodular functions is log supermodular, and the integral of a log supermodular function is log supermodular<sup>15</sup>, it follows that  $Y(F, \phi)$  is log supermodular. Thus, by log supermodularity,  $\frac{\partial \ln Y(F, \phi)}{\partial F}$  is increasing in  $\phi$ .

The second part of the proposition builds on the first part:

$$\frac{Y(F, \phi)}{F} = Y(F, \phi)F^{-1} \quad (57)$$

Since  $Y(F, \phi)$  is log supermodular, and  $F^{-1}$  is trivially log supermodular, it follows that average productivity is log supermodular as a product of two log supermodular functions. Thus, by log supermodularity,  $\frac{\partial \ln(\frac{Y(F, \phi)}{F})}{\partial F}$  is increasing in  $\phi$ . Since the derivative is negative, this implies that the sensitivity of average productivity to the level of funding is higher in less distorted economies.

## B.2 Proof of Propositions 2 and 3

1. To show that financial integration exacerbates volatility differences, I begin by showing that (at autarkic funding levels) funding is more sensitive to the price of liquidity in emerging markets. Since output is more sensitive to funding (Proposition 1), and since, by assumption, mean levels of funding remain unchanged following financial integration, the proposition follows.

In equilibrium, the marginal return to funding is equal to its market price  $r$ :

$$Ay(F, \phi) = r \quad (58)$$

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<sup>15</sup>For proof see Karlin and Rinott [1980].

It follows that the derivative of  $F$  with respect to  $r$  is:

$$\frac{\partial F}{\partial r} = \frac{1}{\frac{\partial r}{\partial F}} = \frac{1}{\frac{\partial A_y(F, \phi)}{\partial F}} \quad (59)$$

Recall that if  $y(F, \phi)$  is log supermodular,  $\frac{\partial \ln y(F, \phi)}{\partial F}$  is increasing in  $\phi$  (see, for example, Costinot [2009]). Property 1 therefore implies that:

$$\frac{\frac{\partial A_{em}y(F, \phi_{em})}{\partial F}}{A_{em}y(F, \phi_{em})} = \frac{\frac{\partial y(F, \phi_{em})}{\partial F}}{y(F, \phi_{em})} > \frac{\frac{\partial y(F, \phi_d)}{\partial F}}{y(F, \phi_d)} = \frac{\frac{\partial A_dy(F, \phi_d)}{\partial F}}{A_dy(F, \phi_d)} \quad (60)$$

Since equilibrium requires that  $A_{em}y(F, \phi_{em}) = A_dy(F, \phi_d) = r$ , it follows that

$$\frac{\partial A_{em}y(F, \phi_{em})}{\partial F} > \frac{\partial A_dy(F, \phi_d)}{\partial F} \quad (61)$$

It follows that:

$$\frac{\partial F_d}{\partial r} = \frac{1}{\frac{\partial A_dy(F, \phi_d)}{\partial F}} > \frac{1}{\frac{\partial A_{em}y(F, \phi_{em})}{\partial F}} = \frac{\partial F_{em}}{\partial r} \quad (62)$$

Since the response of  $F$  to  $r$  is negative, it follows that  $F_{em}$  is more sensitive to changes in  $r$ . By construction,  $F_{em}$  and  $F_d$  are similarly affected by shocks to relative productivity (which cause a substitution between  $F_d$  and  $F_{em}$ ). Thus, since these are the only two sources of variation in  $F$ , under the assumption that  $Q_i = F_i^a$  are identically distributed,

$$var(\ln F_{em}) - var(\ln F_d) > var(\ln F_{em}^a) - var(\ln F_d^a) = 0 \quad (63)$$

To see that financial integration exacerbates the difference in output volatility, note that:

$$var(\ln Y) = \frac{\partial \ln Y}{\partial \ln F} var(\ln F) + var(\ln A) \quad (64)$$

Decompose volatility in  $F$  into volatility conditional on  $Q$  shocks and volatil-

ity conditional on relative TFP shocks:

$$var(\ln F) = var(\ln F|Q) + var(\ln F|A) \quad (65)$$

$$var(\ln Y_{em}) - var(\ln Y_d) - (var(\ln A_{em}) - var(\ln A_d)) = \quad (66)$$

$$\frac{\partial \ln Y_{em}}{\partial \ln F} (var(\ln F_{em}|Q) + var(\ln F_{em}|A)) - \frac{\partial \ln Y_d}{\partial \ln F} (var(\ln F_d|Q) + var(\ln F_d|A)) \quad (67)$$

$$= \frac{\partial \ln Y_{em}}{\partial \ln F} var(\ln F_{em}|A) - \frac{\partial \ln Y_d}{\partial \ln F} var(\ln F_d|A) + \quad (68)$$

$$var(\ln F|Q) \left( \frac{\partial \ln Y_{em}}{\partial \ln F} - \frac{\partial \ln Y_d}{\partial \ln F} \right) \quad (69)$$

Since the last term is positive, we have that:

$$\begin{aligned} & var(\ln Y_{em}) - var(\ln Y_d) - (var(\ln A_{em}) - var(\ln A_d)) \\ & > \frac{\partial \ln Y_{em}}{\partial \ln F} var(\ln F_{em}|A) - \frac{\partial \ln Y_d}{\partial \ln F} var(\ln F_d|A) \end{aligned} \quad (70)$$

The following lemma will be useful to conclude the proof:

**Lemma 6** (a)  $var(\ln F_{em}|A) > var(\ln F_{em}^a)$

(b)  $var(\ln F_d|A) < var(\ln F_d^a)$

**Proof:** To see this, consider a benchmark in which economy  $i$  integrates with an economy with an **identical** sensitivity to  $r$  shocks. In this hypothetical case, shocks to domestic and foreign liquidity supply adjust equally between the two countries. Using the assumption that  $Q_i$  are perfectly correlated, it follows that:

$$var(F_i) = var\left(\frac{1}{2}(Q_i + Q_j)\right) = \frac{1}{4}(var(2Q_i)) = var(Q_i) = var(F_i^a) \quad (71)$$

The lemma above is proved using comparative statics with this benchmark. Since shocks to liquidity supply have a greater effect on emerging markets, the volatility of  $var(F_{em})$  is greater than this benchmark, and

since shocks to liquidity supply have a smaller effect on developed markets, the volatility of  $var(F_d)$  is lower than this benchmark. As mean liquidity levels stay the same, the lemma (as stated in logs) immediately follows.

Using the above lemma, the expression in equation 70 is greater than the expression below, in which  $var(\ln F_i|A)$  are replaced with autarkic values:

$$(70) > \frac{\partial \ln Y_{em}}{\partial \ln F} var(\ln F_{em}^a) - \frac{\partial \ln Y_d}{\partial \ln F} var(\ln F_d^a) \quad (72)$$

$$= var(\ln Y_{em}^a) - var(\ln Y_d^a) - (var(\ln A_{em}) - var(\ln A_d)) \quad (73)$$

$$\Rightarrow var(\ln Y_{em}) - var(\ln Y_d) > var(\ln Y_{em}^a) - var(\ln Y_d^a) \quad (74)$$

Which concludes the proof.

2. (a) To see that financial integration increases volatility of funding in the emerging market region, note that both  $var(F_{em}|A) > var(F_{em}^a|A) = 0$ , and  $var(F_{em}|Q) > var(F_{em}^a|Q)$ . To see that financial integration increases the volatility of output in the emerging market region, note that since  $var(A)$  remains the same, and since the level  $F$  is unchanged, from equation 64 output volatility increases as well.
- (b) The effect of financial integration on  $var(F_d)$  is ambiguous: the volatility of  $F_d$  conditional on holding technology levels constant is smaller, so  $var(F_d|A) < var(F_d^a|A)$ . However, through the standard RBC channel,  $var(F_d|Q) > var(F_d^a|Q) = 0$ . If shocks to relative TFP are sufficiently small, the first effect dominates so  $var(F_d) < var(F_d^a)$ . In this case, from equation 64 (and the assumption that the mean level of  $F$  is unchanged), it follows that output volatility decreases as well.

### B.3 Proof of Proposition 4

The following lemma will be useful in various proofs:

**Lemma 7** For every  $F$  and  $\phi' \leq \phi$ ,

$$Y(F, \phi') \geq Y(F, \phi) \quad (75)$$

To prove this lemma, let  $\phi > \phi'$  and consider the function:

$$Y(F, \phi') - Y(F, \phi) \quad (76)$$

Recall that this function is 0 for  $F = 0$  and for  $F = 1$ . Taking a first order condition yields:

$$y(F, \phi') - y(F, \phi) = 0 \quad (77)$$

This point is a local maximum, as the second derivative is negative by Property 1. To see this, using equation 77:

$$\frac{\frac{\partial y(F, \phi')}{\partial F} - \frac{\partial y(F, \phi)}{\partial F}}{y(F, \phi)} = \frac{\frac{\partial y(F, \phi')}{\partial F}}{y(F, \phi')} - \frac{\frac{\partial y(F, \phi)}{\partial F}}{y(F, \phi)} = \frac{\partial \ln y(F, \phi')}{\partial F} - \frac{\partial \ln y(F, \phi)}{\partial F} < 0 \quad (78)$$

The inequality stems from Property 1.

Thus, the function reaches a maximum at the point  $y(F, \phi') = y(F, \phi)$ . The minima of this function are therefore at  $F = 0$  and  $F = 1$ , at which the function takes the value of 0. It follows that the function is always weakly greater than 0:

$$Y(F, \phi') - Y(F, \phi) \geq 0 \quad (79)$$

Which concludes the proof.

**Lemma 8** Consider the problem:

$$\max_{\phi} \int_0^F y(F', \phi) dF' - \lambda(\phi) \quad (80)$$

The solution  $\phi^*$  is increasing in  $F$  for some range  $F \in (\tilde{F}, 1]$ .

Using the proof of Lemma 7, for each pair  $\phi_i > \phi_j$  there is a point  $0 < F_{i,j} < 1$  such that  $Y(F, \phi)$  has increasing differences for  $F > F_{i,j}$  and  $\phi \in \{\phi_i, \phi_j\}$ . Let  $\tilde{F}$  denote the maximum of these  $F_{i,j}$ . In the region  $(\tilde{F}, 1]$ , there are increasing

differences for all  $\phi$  within the set of possible values. By Sundaram (1996),  $\phi^*$  is increasing in  $F$  on that region.

Note that, for any  $r$ ,  $\phi^*$  is the solution to:

$$\max_{\phi} \int_0^F y(F', \phi) dF' - \lambda(\phi) - rF \quad (81)$$

This is because  $rF$  is a constant in this problem.

Recall the assumption that  $E(Q_d) = E(Q_{em}) = Q$ . Now, assume that  $Q \in (\tilde{F}, 1]$ . In this range, a drop in  $r$  is associated with an increase in  $F^*$ . If  $\frac{A_d}{A_{em}}$  is sufficiently small, integration will be associated with a drop in  $r$  from the developed market's perspective. It follows that  $\phi^*$  increases.

## B.4 Proof of Proposition 5

For what follows, denote by  $\phi_d^w$  the level of distortions in the deteriorated “weak” financial system, and by  $\phi_d^i$  the autarkic “intact” level of financial distortions. Normalize  $\lambda(\phi_d^w) = 0$  and  $\lambda(\phi_d^i) = \lambda$ .

I begin with the first part of the proposition. By equations 77 and 78, there is a unique point  $F_0 \in (0, 1)$  such that:

$$y_d(F_0, \phi_d^i) = y_d(F_0, \phi_d^w) \quad (82)$$

For every  $F < F_0$ ,  $y(F, \phi_d^i) > y(F, \phi_d^w)$  and for every  $F > F_0$ ,  $y(F, \phi_d^i) < y(F, \phi_d^w)$ .

Recall that in this setup, prior to financial integration the financial system in the developed world was endogenously intact, and it endogenously deteriorated following a drop in  $r$ . It turns out that these dynamics are possible only if  $r$  is such that funding levels exceed  $F_0$  (when the financial system is intact and the economy is integrated):

**Lemma 9** *There is an endogenous weakening of the financial system (in the developed world) only if  $r \leq y(F_0, \phi_d^i) = y(F_0, \phi_d^w)$ .*

Here,  $r$  denotes the rate of return on funding when the financial system in the developed world is intact.

**Proof:** Assume  $r > y(F_0, \phi_d^i)$ , and it will be shown that in this case there is no endogenous financial deterioration. Denote by  $r^a$  the return to funding under autarky in the developed world. We know that given  $r^a$ , the optimal choice of financial quality is  $\phi_d = \phi_d^i$ :

$$\pi(r^a, \phi_d^i) > \pi(r^a, \phi_d^w) \quad (83)$$

$$\Rightarrow \max_F \int_0^F y(F', \phi_d^i) dF' - r^a F - \lambda > \max_F \int_0^F y(F', \phi_d^w) dF' - r^a F \quad (84)$$

The standard optimality condition is  $y(F, \phi_d) = r^a$ . Denote this  $F$  by  $F^*(r, \phi_d)$ .

Thus, the inequality in equation 84 can be rewritten as:

$$\int_{r^a}^{\infty} (y(F^*(r', \phi_d^i), \phi_d^i) - y(F^*(r', \phi_d^w), \phi_d^w)) dr' > \lambda \quad (85)$$

From the assumption that  $r > y(F_0, \phi_d^i)$ , it follows that  $r^a > y(F_0, \phi_d)$ , because  $r^a > r$  (there is a drop in  $r$  upon financial integration). For  $r > y(F_0, \phi_d^i)$ , it is also the case that:

$$F^*(r, \phi_d^i) > F^*(r, \phi_d^w) \quad (86)$$

This is because, since  $F^*(r, \phi_d^i) < F_0$ ,

$$y(F^*(r, \phi_d^i), \phi_d^w) < y(F^*(r, \phi_d^i), \phi_d^i) \quad (87)$$

Thus, since  $y$  is decreasing in  $F$ , the inequality in equation 86 holds true.

Note that equation 87 holds for any  $y(F_0, \phi_d) < r < r^a$ . Thus,

$$\int_0^{F^*(r, \phi_d^i)} y(F', \phi_d^i) dF' - r F^*(r, \phi_d^i) - \int_0^{F^*(r, \phi_d^w)} y(F', \phi_d^w) dF' - r F^*(r, \phi_d^w) = \quad (88)$$

$$\int_r^{\infty} y(F^*(r', \phi_d^i), \phi_d^i) dr' - \int_r^{\infty} y(F^*(r', \phi_d^w), \phi_d^w) dr' = \quad (89)$$

$$\int_{r^a}^{\infty} (y(F^*(r', \phi_d^i), \phi_d^i) - y(F^*(r', \phi_d^w), \phi_d^w)) dr' + \quad (90)$$

$$\int_r^{r^a} (y(F^*(r', \phi_d^i), \phi_d^i) - y(F^*(r', \phi_d^w), \phi_d^w)) dr' \quad (91)$$

By equation 85, the first term is greater than  $\lambda$ . The second term is positive by equation 87. Thus, the sum above is greater than  $\lambda$ . It follows that choosing  $\phi_d = \phi_d^i$  is still preferable to choosing  $\phi_d = \phi_d^w$ . I conclude that an endogenous financial deterioration is not possible if  $r > y(F_0, \phi_d^i)$ .

To conclude the proof, note that for  $r < y(F_0, \phi_d^i)$ ,

$$F^*(r, \phi_d^i) < F^*(r, \phi_d^w) \quad (92)$$

Thus, the deterioration in the quality of the financial system is associated with an increase in  $F$ .

To see the second part of the proposition, note that for  $\frac{A_d}{A_{em}}$  sufficiently large,

$$y_d(1, \phi_d^w) > y_{em}(1, \phi_{em}) \quad (93)$$

From continuity, there exists  $\epsilon > 0$  such that for every  $1 - \epsilon < F < 1$ ,

$$y_d(1, \phi_d^w) > y_{em}(F, \phi_{em}) \quad (94)$$

It follows that for  $Q_w > 2 - \epsilon$ , the developed market will be satiated with funding. Output is weakly higher than in the intact case (note that the conditions under which the weakened financial system is satiated with funding are weaker than the conditions under which the intact economy is satiated with funding, because, since  $F_0 < 1$ ,  $y_d(1, \phi_d^w) > y_d(1, \phi_d^i)$ ). Under satiation, the developed economy is stable with respect to small shocks to the global supply of funding, as the economy remains satiated as long as  $Q_w$  satisfies:

$$y_d(1, \phi_d^w) > y_{em}(Q_w - 1, \phi_{em}) \quad (95)$$

Similarly, the level of funding is unaffected by shocks to relative TFP. The volatility of output is therefore smaller both with respect to liquidity supply shocks and with respect to shocks to relative TFP.



## B.5 Proof of Lemma 1

Recall the notation from the proof of Proposition 5:  $\phi_d^w$  denotes the level of distortions in the deteriorated “weak” financial system, and  $\phi_d^i$  denotes the autarkic “intact” level of financial distortions.

Given  $\phi_d$ , world output maximization solves:

$$Y_w(\phi_d) = \max_{F_d, F_{em}} Y_w(\phi_d, F_d, F_{em}) = \quad (96)$$

$$\max_{F_d, F_{em}} A_d \int_0^{F_d} y(F', \phi_d) dF' + A_{em} \int_0^{F_{em}} y(F', \phi_{em}) dF' \quad (97)$$

s.t.

$$F_d + F_{em} = Q_w \quad (98)$$

$$F_i \leq 1 \quad (99)$$

Under autarky there is an additional constraint which is:

$$F_i = Q_i \quad (100)$$

It is easy to see that for any *given* couple  $(F_d, F_{em})$  which satisfy constraints 98-99 or 98-100, the output produced is higher when the financial system in the developed market is intact:

$$Y_w(\phi_d^i, F_d, F_{em}) \geq Y_w(\phi_d^w, F_d, F_{em}) \quad (101)$$

Denote by  $(F_d^*(\phi_d), F_{em}^*(\phi_d))$  the optimal allocation of funding given  $\phi_d$ . From the optimality of  $F_i^*(\phi_d^i)$ :

$$Y_w(\phi_d^i) = Y_w(\phi_d^i, F_d^*(\phi_d^i), F_{em}^*(\phi_d^i)) \geq Y_w(\phi_d^i, F_d^*(\phi_d^w), F_{em}^*(\phi_d^w)) \quad (102)$$

And, from equation 101:

$$Y_w(\phi_d^i, F_d^*(\phi_d^w), F_{em}^*(\phi_d^w)) \geq Y_w(\phi_d^w, F_d^*(\phi_d^w), F_{em}^*(\phi_d^w)) = Y_w(\phi_d^w) \quad (103)$$

It follows that world output is higher when the financial system in the developed

market is intact:

$$\Rightarrow Y_w(\phi_d^i) \geq Y_w(\phi_d^w) \quad (104)$$

## B.6 Proof of Proposition 6

Recall the notation from the proof of Proposition 5:  $\phi_d^w$  denotes the level of distortions in the deteriorated “weak” financial system, and  $\phi_d^i$  denotes the autarkic “intact” level of financial distortions.

Let  $F_0$  be given by the condition in equation 77:

$$y(F_0, \phi_d^i) = y(F_0, \phi_d^w) \quad (105)$$

Consider a shock to the global supply of liquidity such that  $Q_w < F_0$ . In this range, the marginal product of funding in the developed world is higher under intact financial institutions. It follows that funding is higher:

$$F_d^*(Q_w, \phi_d^i) > F_d^*(Q_w, \phi_d^w) \quad (106)$$

Since output decreases with the level of distortion by Lemma 7,

$$Y_d(F_d^*(Q_w, \phi_d^i), \phi_d^i) > Y_d(F_d^*(Q_w, \phi_d^i), \phi_d^w) \quad (107)$$

Since output is increasing in the level of funding,

$$Y_d(F_d^*(Q_w, \phi_d^i), \phi_d^w) > Y_d(F_d^*(Q_w, \phi_d^w), \phi_d^w) \quad (108)$$

It follows that output is higher under intact financial institutions:

$$Y_d(F_d^*(Q_w, \phi_d^i), \phi_d^i) > Y_d(F_d^*(Q_w, \phi_d^w), \phi_d^w) \quad (109)$$

Similarly, a shock to relative TFP such that  $F_d^*(Q_w, \phi_d^i) < F_0$  is amplified by lack of high quality financial institutions.

## B.7 Proof of Theorem 1

As  $g(\cdot)$  is positive and decreasing, it can be arbitrarily well approximated by a sum of the form:

$$g(x) = \sum_{i=0}^n g_i \chi_{[0, x_i]}(x) \quad (110)$$

Where  $\chi_{[0, x_i]}(x) = 1$  if  $x \in [0, x_i]$  and  $\chi_{[0, x_i]}(x) = 0$  otherwise. For convenience, denote:

$$\sigma_\phi^i(F) = \int_0^{x_i} \sigma_\phi(x, F) dx \quad (111)$$

Note that:

$$y(F, \phi) = \int_0^1 \sigma_\phi(x, F) g(x) dx = \sum_{i=1}^n \sigma_\phi^i(F) g_i \quad (112)$$

Let  $\phi \geq \phi'$  and  $F \geq F'$ . To satisfy Property 1, I need to show that:

$$y(F, \phi) y(F', \phi') - y(F', \phi) y(F, \phi') \geq 0 \quad (113)$$

Using the expression above, this can be rewritten as:

$$\left( \sum_{i=1}^n \sigma_\phi^i(F) g_i \right) \left( \sum_{i=1}^n \sigma_{\phi'}^i(F') g_i \right) - \left( \left( \sum_{i=1}^n \sigma_\phi^i(F') g_i \right) \left( \sum_{i=1}^n \sigma_{\phi'}^i(F) g_i \right) \right) \geq 0 \quad (114)$$

The above righthand side is a some of expressions of the form:

$$g_i g_j (\sigma_\phi^i(F) \sigma_{\phi'}^j(F') + \sigma_\phi^j(F) \sigma_{\phi'}^i(F') - \sigma_\phi^i(F') \sigma_{\phi'}^j(F) - \sigma_\phi^j(F') \sigma_{\phi'}^i(F))$$

I argue that each of these expressions is non-negative, implying the non-negativity of the sum. To see this, assume by way of contradiction that for some  $i$  and  $i \leq j$ , the above expression is negative. Thus, neither  $g_i$  nor  $g_j$  can be 0; thus, they are strictly positive, so dividing through by  $g_i$  and  $g_j$  we get:

$$\sigma_\phi^i(F) \sigma_{\phi'}^j(F') + \sigma_\phi^j(F) \sigma_{\phi'}^i(F') - \sigma_\phi^i(F') \sigma_{\phi'}^j(F) - \sigma_\phi^j(F') \sigma_{\phi'}^i(F) < 0 \quad (115)$$

Note that:

$$\begin{aligned} & \sigma_\phi^i(F)\sigma_{\phi'}^j(F') + \sigma_\phi^j(F)\sigma_{\phi'}^i(F') = \\ & \sigma_\phi^i(F)\sigma_{\phi'}^i(F') + \sigma_\phi^j(F)\sigma_{\phi'}^j(F') + \int_{x_i}^{x_j} \sigma_\phi(x, F)dx \int_{x_i}^{x_j} \sigma_{\phi'}(x, F')dx \end{aligned}$$

Let  $X_i = [0, x_i]$ ,  $X_j = [0, x_j]$  and  $X_{i,j} = [x_i, x_j]$ . Using the above, the inequality in equation B.7 can be rewritten as:

$$D(X_i) + D(X_j) - D(X_{i,j}) < 0 \quad (116)$$

This implies that:

$$D(X_j) < D(X_{i,j}) - D(X_i) \quad (117)$$

This is a contradiction, as by Assumption 1 the left hand side is greater than 0, and by Assumption 2 the right hand side is less than 0.

## B.8 Proof of Lemma 2

Note that, for  $F \leq 0.5$ :

$$\int_0^x \sigma_\phi(z, F)dz = Pr_\phi(z \leq x | s(z) = G) \quad (118)$$

And for  $F > 0.5$ :

$$\int_0^x \sigma_\phi(z, F)dz = Pr_\phi(z \leq x | s(z) = B) \quad (119)$$

Assumptions 1 and 2 hold trivially if both  $F, F' \leq 0.5$  or  $F, F' > 0.5$ . It is left to show that Assumptions 1 and 2 hold for  $F' \leq 0.5$  and  $F > 0.5$ .

From the proof of Theorem 1, it is sufficient to show that for any  $x$  and  $x'$ :

$$\begin{aligned} & \int_0^x \sigma_\phi(z, F)dz \int_0^{x'} \sigma_{\phi'}(z, F')dz + \int_0^{x'} \sigma_\phi(z, F)dz \int_0^x \sigma_{\phi'}(z, F')dz - \\ & \int_0^x \sigma_\phi(z, F')dz \int_0^{x'} \sigma_{\phi'}(z, F)dz - \int_0^{x'} \sigma_\phi(z, F')dz \int_0^x \sigma_{\phi'}(z, F)dz \geq 0 \end{aligned}$$

Rewriting,

$$\begin{aligned} & Pr_\phi(z \leq x|s(z) = B)Pr_{\phi'}(z \leq x'|s(z) = G) + Pr_\phi(z \leq x'|s(z) = B)Pr_{\phi'}(z \leq x|s(z) = G) \geq \\ & Pr_\phi(z \leq x|s(z) = G)Pr_{\phi'}(z \leq x'|s(z) = B) + Pr_\phi(z \leq x'|s(z) = G)Pr_{\phi'}(z \leq x|s(z) = B) \end{aligned}$$

This inequality holds, as:

$$Pr_\phi(z \leq x|s(z) = B)Pr_{\phi'}(z \leq x'|s(z) = G) \geq Pr_\phi(z \leq x'|s(z) = G)Pr_{\phi'}(z \leq x|s(z) = B)$$

And

$$Pr_\phi(z \leq x'|s(z) = B)Pr_{\phi'}(z \leq x|s(z) = G) \geq Pr_\phi(z \leq x|s(z) = G)Pr_{\phi'}(z \leq x'|s(z) = B)$$

This is the case because  $Pr_\phi(z \leq x|s(z) = B) \geq Pr_{\phi'}(z \leq x|s(z) = B)$  and  $Pr_{\phi'}(z \leq x|s(z) = G) \geq Pr_\phi(z \leq x|s(z) = G)$  (both for  $x$  and  $x'$ ).

## B.9 Proof of Lemma 3

To simplify notation, I write  $\theta(x, F) = \int_0^x \sigma_{eff}(z, F)dz$ . In this model, it is easy to see that Assumptions 1 and 2 are satisfied if for any  $\phi' \leq \phi$ ,  $F' \leq F$ ,  $x$  and  $x'$ :

$$\begin{aligned} & ((1 - \phi')\theta(x', F') + \phi'x')((1 - \phi)\theta(x, F) + \phi x) + \tag{120} \\ & ((1 - \phi')\theta(x, F') + \phi'x)((1 - \phi)\theta(x', F) + \phi x') \geq \\ & ((1 - \phi')\theta(x', F) + \phi'x')((1 - \phi)\theta(x, F') + \phi x) + \\ & ((1 - \phi')\theta(x, F) + \phi'x)((1 - \phi)\theta(x', F') + \phi x') \end{aligned}$$

Rewriting the condition:

$$\begin{aligned} & (1 - \phi')(1 - \phi)\theta(x', F')\theta(x, F) + \phi x(1 - \phi')\theta(x', F') + \phi'x'(1 - \phi)\theta(x, F) + \phi\phi'xx' + \\ & (1 - \phi')(1 - \phi)\theta(x, F')\theta(x', F) + \phi x'(1 - \phi')\theta(x, F') + \phi'x(1 - \phi)\theta(x', F) + \phi\phi'xx' \geq \\ & (1 - \phi')(1 - \phi)\theta(x', F)\theta(x, F') + \phi x(1 - \phi')\theta(x', F) + \phi'x'(1 - \phi)\theta(x, F') + \phi\phi'xx' + \end{aligned}$$

$$(1 - \phi')(1 - \phi)\theta(x, F)\theta(x', F') + \phi x'(1 - \phi')\theta(x, F) + \phi' x(1 - \phi)\theta(x', F') + \phi\phi' x x'$$

This condition simplifies to:

$$\phi x(1 - \phi')\theta(x', F') + \phi' x'(1 - \phi)\theta(x, F) + \phi x'(1 - \phi')\theta(x, F') + \phi' x(1 - \phi)\theta(x', F) \geq$$

$$\phi x(1 - \phi')\theta(x', F) + \phi' x'(1 - \phi)\theta(x, F') + \phi x'(1 - \phi')\theta(x, F) + \phi' x(1 - \phi)\theta(x', F')$$

Or:

$$\phi(1 - \phi')(x\theta(x', F') + x'\theta(x, F')) + \phi'(1 - \phi)(x'\theta(x, F) + x\theta(x', F)) \geq$$

$$\phi(1 - \phi')(x\theta(x', F) + x'\theta(x, F')) + \phi'(1 - \phi)(x'\theta(x, F') + x\theta(x', F'))$$

Rearranging:

$$\phi(1 - \phi')(x'(\theta(x, F') - \theta(x, F)) + x(\theta(x', F') - \theta(x', F))) \geq$$

$$\phi'(1 - \phi)(x'(\theta(x, F') - \theta(x, F)) + x(\theta(x', F') - \theta(x', F)))$$

Note that, as  $\theta(x, F') \geq \theta(x, F)$  for all  $x$ ,

$$x'(\theta(x, F') - \theta(x, F)) + x(\theta(x', F') - \theta(x', F)) \geq 0 \quad (121)$$

Thus, the inequality is satisfied if and only if:

$$\phi(1 - \phi') \geq \phi'(1 - \phi) \quad (122)$$

Which holds true as  $\phi \geq \phi'$ .

## B.10 Proof of Lemma 4

Begin by considering the case  $\phi \leq 1$ . First, note that for every  $F$ , there is a threshold  $\tilde{F}$  such that project  $(x, b)$  is implemented if and only if  $x \leq \tilde{F}$  and  $b \leq \tilde{F}$ . For  $\tilde{F} < \phi$ ,

$$F = Pr(x \leq \tilde{F}, b \leq \tilde{F}) = \tilde{F} \cdot \frac{1}{\phi} \tilde{F} = \frac{1}{\phi} \tilde{F}^2 \Rightarrow \tilde{F} = \sqrt{\phi} \sqrt{F} \quad (123)$$

Note that  $\tilde{F} < \phi$  if and only if  $F < \phi$ . For  $F > \phi$ , it is easy to see that  $\tilde{F} = F$ . For  $F < \phi$ , output is given by the following expression:

$$Y(\tilde{F}) = \int_0^{\tilde{F}} Pr(b \leq \tilde{F}) Ag(x) dx = \frac{1}{\phi} \tilde{F} \int_0^{\tilde{F}} Ag(x) dx = \frac{A}{\phi} \tilde{F}^{1+\alpha} \quad (124)$$

It follows that, for  $F < \phi$ :

$$Y(F, \phi) = A\phi^{\frac{\alpha-1}{2}} F^{\frac{1+\alpha}{2}} \quad (125)$$

The derivative of  $Y$  with respect to  $F$  is therefore given by:

$$y(F, \phi) = \frac{1+\alpha}{2} A\phi^{\frac{\alpha-1}{2}} F^{\frac{\alpha-1}{2}} \quad (126)$$

$$\Rightarrow \ln y(F, \phi) = \ln\left(\frac{1+\alpha}{2} A\right) - \frac{1-\alpha}{2} \ln \phi - \frac{1-\alpha}{2} \ln F \quad (127)$$

The derivative of above with respect to  $F$  is:

$$\frac{\partial \ln y(F, \phi)}{\partial F} = -\frac{1-\alpha}{2F} \quad (128)$$

The above does not depend on  $\phi$  as long as  $F < \phi$ ; the log supermodularity condition is trivially satisfied. However, Note that for a higher  $\phi$ , there are more values of  $F$  such that  $F < \phi$ . Let there be  $\phi$  and  $\phi'$  such that  $\phi' < F < \phi$ . For  $\phi'$ , it is easy to see that the derivative of  $\ln y(F, \phi')$  is given by the following expression:

$$y(F, \phi') = A\alpha F^{-(1-\alpha)} \Rightarrow \ln y(F, \phi') = \ln(A\alpha) - (1-\alpha) \ln F \quad (129)$$

$$\Rightarrow \frac{\partial \ln y(F, \phi')}{\partial F} = -\frac{1-\alpha}{F} < -\frac{1-\alpha}{2F} = \frac{\partial \ln y(F, \phi)}{\partial F} \quad (130)$$

Thus, the derivative of  $\ln y$  with respect to  $F$  is higher in the more distorted economy  $\phi$ , consistent with Property 1.

Consider now the range  $\phi \geq 1$ . In this range, for  $\tilde{F} < 1$ ,  $F$  is given by equation 123, output is given by equation 124 and  $\frac{\partial \ln y}{\partial F}$  is given by equation 128. In this range,  $\frac{\partial \ln y}{\partial F}$  is constant with respect to  $\phi$ , so the log supermodular condition is trivially satisfied.

Note that  $\tilde{F} < 1$  if and only if  $\sqrt{\phi F} < 1$ , or  $F < \frac{1}{\phi}$ . This condition is violated

for more values of  $F$  if  $\phi$  is larger. For  $F > \frac{1}{\phi}$ , the marginal product of funding is constant; the collateral constraint is binding for all implemented projects, so the productivity of the projects implemented with each unit of funding is the same. Thus, in the range  $F > \frac{1}{\phi}$ ,

$$\frac{\partial \ln y(F, \phi)}{\partial F} = 0 > -\frac{1 - \alpha}{2F} \quad (131)$$

The right hand side is equal to the derivative of  $\ln y$  for the case  $F < \frac{1}{\phi}$ . It follows that the log supermodularity condition is satisfied for  $\frac{1}{\phi} < F < \frac{1}{\phi'}$ .

## B.11 Proof of Lemma 5

Output is given by the following expression:

$$Y(F, \phi) = \sum_{i=0}^{\phi} \int_{\frac{i}{\phi}}^{\frac{i}{\phi} + \frac{F}{\phi}} Ag(x) dx \quad (132)$$

This is because each local bank has  $\frac{F}{\phi}$  units of liquidity to allocate, and uses it to implement the first  $\frac{F}{\phi}$  in the sample of projects available to it.

The marginal product of funding is given by:

$$y(F, \phi) = \frac{1}{\phi} \sum_{i=0}^{\phi} Ag\left(\frac{i}{\phi} + \frac{F}{\phi}\right) = \frac{A}{\phi} \sum_{i=0}^{\phi} e^{-\left(\frac{i}{\phi} + \frac{F}{\phi}\right)} \quad (133)$$

$$= \frac{Ae^{-\frac{F}{\phi}}}{\phi} \sum_{i=0}^{\phi} e^{-\frac{i}{\phi}} \quad (134)$$

It follows that:

$$\ln y(F, \phi) = \ln\left(\frac{A}{\phi} \sum_{i=0}^{\phi} e^{-\frac{i}{\phi}}\right) + \ln e^{-\frac{F}{\phi}} = c - \frac{F}{\phi} \quad (135)$$

The derivative of above with respect to  $F$  is  $-\frac{1}{\phi}$ , which is increasing in  $\phi$ . The log supermodularity condition is satisfied, in accordance with Property 1.



## C A monetary model of liquidity supply

In this section, I develop a model of liquidity supply, in which liquidity supply fluctuations are caused by three primitive shocks: shocks to the money supply, shocks to consumers' risk aversion<sup>16</sup> and shocks to the private sector's ability to generate promises for future repayment. Recall that the model makes three assumptions about the distribution of liquidity supply:

1. The distribution of liquidity supply is unchanged by financial integration.
2. Liquidity supply is independent from both domestic and foreign productivity,  $A_i$ .
3. Liquidity supply is perfectly correlated across regions.

Consider a model in which labor (denoted  $L$ ) is the only productive input. Given  $L_i$  hired units of labor, output in country  $i$  is given by:

$$Y_i = A_i f_i(L_i) \tag{136}$$

In this model, liquidity is money used to hire labor; thus, in this formulation,  $f_i$  already captures the efficiency of the financial system in allocating liquidity (in other words,  $f$  is log supermodular in  $L$  and  $\phi$ ).

**Assumption 3**    1. *The price of a unit of labor in terms of money,  $w$ , is determined at the beginning of the period, before all shocks are realized. Agents agree to supply any amount of labor for the wage  $w$ .*

2. *The price of output is fixed within a period, and is normalized to one.*

Agents live for one period and consume at the end of their lives. The preferences of agents in region  $i$  are given by:

$$E(u_i(c_i) - v_i(L_i)) \tag{137}$$

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<sup>16</sup>The analysis of Broner et al. [Forthcoming] suggests that shocks to the risk aversion of international investors is indeed an important driving source of supply driven volatility in emerging markets.

I assume that  $u_i(c_i)$  takes the following stark form:

$$u_i(c_i) = \begin{cases} c_i & \text{if } c \geq c_{0,i}; \\ -\infty & \text{otherwise.} \end{cases} \quad (138)$$

In this formulation,  $c_{0,i}$  captures the level of risk aversion of households in region  $i$ . To see this, consider the comparison between two agents, one denoted  $h$  with  $c_{0,h} = c_{0,h}$  and one denoted  $l$  with  $c_{0,l} < c_{0,h}$ .

**Definition 2** *Agent  $h$  is more risk averse than agent  $l$  if the following condition holds: for any certain consumption payment  $c$ , and any lottery  $q$ , if agent  $h$  prefers  $q$  over  $c$  then so does agent  $l$ .*

To see that, according to this standard definition, the condition  $c_{0,h} > c_{0,l}$  implies that agent  $h$  is more risk averse than agent  $l$ , note the following claim:

**Claim 2** *Agent  $i$  prefers a lottery  $q$  over a certainty payment of  $c$  if and only if the lottery  $q$  never delivers a payment of less than  $c_{0,i}$ , and  $E(q) > c$ .*

**Proof:** Trivially, if the above condition holds, the agent will prefer the lottery: if  $c > c_{0,i}$  he is risk neutral between the two lotteries, and if  $c \leq c_{0,i}$  his utility from consuming  $c$  is  $-\infty$  whereas it is positive given the lottery. If the above condition is violated, it means that one of the following holds: either  $E(q)$  delivers a payment of less than  $c_{0,i}$  with positive probability, or  $E(q) < c$ . If  $E(q)$  delivers a payment of less than  $c_{0,i}$  with positive probability, then the agent's expected utility from the lottery is  $-\infty$ , so it is not preferred over anything. If  $E(q) < c$ , but  $q$  always delivers a payment of more than  $c_{0,i}$ , then it follows that  $c > c_{0,i}$ , so the agent is risk neutral with respect to  $q$  and  $c$  and would prefer  $c$ .

Using this claim, it is easy to see that  $h$  is more risk averse than  $l$ , as the fact that  $q$  never delivers a payment of less than  $c_{0,h}$  implies that it never delivers a payment of less than  $c_{0,l} < c_{0,h}$ , so the set of lotteries and certainty payments in which  $h$  prefers the lottery is included in the set of lotteries and certainty payments in which  $l$  prefers the lottery.

Thus, we will think of  $c_0$  as the level of risk aversion of the agents.

**Corollary 2** *A higher level of  $c_{0,i}$  implies a higher level of risk aversion.*

## C.1 Liquidity supply in the closed economy

After wages are agreed upon and prices are set, the money supply,  $M_i$ , and the level of risk aversion,  $c_{0,i}$ , are realized. Agents can choose to hold their money in a safe ( $M_{h,i}$ ) or buy stocks in the productive sector ( $Q_i$ ):

$$M_i = Q_i + M_{h,i} \quad (139)$$

The level of  $Q_i$  is also the level of liquidity supply which can be used to hire workers. After the productivity shock  $A_i$  is realized, the financial system allocates the liquidity  $Q_i$  to domestic projects who use it to hire workers:

$$Q_i = w_i L_i \quad (140)$$

After production takes place but before workers are paid, there is a shock to the ability of the productive sector to make monetary transfers. With probability  $(1 - \theta)$ , this ability is *intact*; in this case, wages are paid and two rounds of consumption follow. In the first round, households use their money holdings (which include wage payments,  $w_i L_i$ , and money from the safe,  $M_{h,i}$ ) to buy output and consume. In the second round, monetary revenues from sales are redistributed to households as dividends (denoted  $d$  per share), and are used for consumption. The end of the period consumption is given by:

$$c_i = M_{h,i} + w_i L_i + dQ_i \quad (141)$$

With a small probability  $\theta$ , the ability of the productive sector to make monetary transfers *collapses*. This implies two things: first, wages are not paid to workers. Second, revenues from sales cannot be redistributed back to households, so no dividends are paid. There is only one round of consumption, in which households use the money which they had kept in the safe ( $M_{h,i}$ ) to buy consumption goods. It follows that the end of the period consumption is given by:

$$c_i = M_{h,i} \quad (142)$$

Simplistically, the shock to the ability of the productive sector to make mone-

tary transfers can be thought of as a strike in the postal services: households who receive wage payments and dividend payments by mail (and are subject to a cash in advance constraint) do not receive these payments in time to consume before they die. Realistically, this shock is meant to capture a shock to the money supply, in which certain substitutes for money used by the productive sector are no longer valued<sup>17</sup>. For example, prior to the sub-prime crisis, mortgage backed securities were accepted by all as means of payment. In the sub-prime crisis, these securities turned into illiquid assets, and people were no longer willing to hold these assets without understanding the value of their components. Thus, it became harder to trade these assets for consumption goods, which made bonds and cash more desired<sup>18</sup>. In this model, agents hold bonds (“money in the safe”) precisely to insure against events of this kind<sup>19</sup>.

In addition, I assume that the productive sector is endowed with an inventory of  $K$  consumption goods, where  $K > M_i$  for any realization of  $M_i$ . This assumption will allow a simple way to incorporate shocks to  $\theta$  that affect liquidity supply.

Specifically, I assume that  $\theta$  is small with some probability  $\rho$  and  $\theta = 1$  with probability  $1 - \rho$ . The value of  $\theta$  is revealed before agents decide on their portfolio.

To summarize, the timing within a period is as follows:

1. The economy is endowed with an inventory of  $K$  units of consumption goods. The wage  $w_i$  and the price of output (normalized to 1) is set.
2. The initial money supply,  $M_{0,i}$ , and the level of risk aversion,  $c_{0,i}$ , are realized. In addition, the probability of a collapse  $\theta$  is revealed.
3. Agents use some of their money to buy stocks and effectively supply liquidity to the productive sector (and keep the rest in a safe).
4. The productivity shock,  $A_i$ , is realized.

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<sup>17</sup>See Eden [2009] for a complete development of this idea.

<sup>18</sup>See Holmstrom [2008] for a complete development of this idea.

<sup>19</sup>Results similar to those derived in this section can be derived in a more standard framework, in which agents hold money to insure against unemployment risk; however, this motive for hoarding liquidity seems less compelling as the mechanism through which shocks to risk aversion affect liquidity supply. Rather, in this formulation portfolio decisions are motivated by fear of large aggregate disasters, consistent with the view expressed in Barro [2006].

5. The financial system allocates liquidity to projects, and production takes place.
6.
  - With prob.  $(1 - \theta)$  (*intact*): wages are paid, followed by a first round of consumption in which agents trade their wage earnings ( $w_i L_i$ ) and their money holdings ( $M_{h,i}$ ) for consumption. The productive sector redistributes revenues from sales back to households in the form of dividends. A second round of consumption takes place in which the dividends are traded for consumption.
  - With prob.  $\theta$  (*collapse*): the productive sector loses its ability to make monetary transfers. Wages are not paid and revenues from sales cannot be redistributed back to households. There is therefore only one round of consumption, in which households use their money holdings ( $M_{h,i}$ ) to buy consumption goods.

### C.1.1 Equilibrium

**The portfolio decision.** Clearly, the agent will reserve at least enough money to finance  $c_{0,i}$  units of consumption in case of a collapse (as otherwise his expected utility is  $-\infty$ ):

$$M_{h,i} \geq c_{0,i} \tag{143}$$

I begin with the case in which  $\theta$  is small. Denote by  $d$  the realized dividend per share of the productive sector, and let  $Q_i^0$  be the equilibrium level of liquidity supply, which the individual agent takes as given. Agents solve:

$$\max_{Q_i, M_{h,i}} E(c_i - v_i(L_i)) \tag{144}$$

s.t.:

$$M_i = Q_i + M_{h,i} \tag{145}$$

$$c_i = \begin{cases} M_{h,i} + Q_i d + w_i L_i & \text{with prob. } (1 - \theta); \\ M_{h,i} & \text{with prob. } \theta. \end{cases} \tag{146}$$

$$M_{h,i} \geq c_{0,i} \tag{147}$$

Substituting in the first constraint, this problem can be rewritten as:

$$\max_{Q_i} (1 - \theta)(M_i - Q_i + Q_i d + w_i L_i) + \theta(M_i - Q_i) - v_i(L_i) \quad (148)$$

s.t.

$$M_i - Q_i \geq c_{0,i} \quad (149)$$

The derivative of the above with respect to  $Q_i$  is:

$$(1 - \theta)d - 1 \quad (150)$$

Note that, in equilibrium, the dividends per share are given by:

$$d = \frac{M_i}{Q_i^0} \quad (151)$$

**Assumption 4** *With probability  $\rho$ , the value of  $\theta$  is sufficiently small so that, for any realization of  $M_i$  and  $c_{0,i}$ , the derivative of equation 148 with respect to  $Q_i$  is positive at  $Q_i^0 = M_i - c_{0,i}$ .*

$$(1 - \theta) \frac{M_i}{M_i - c_{0,i}} - 1 > 0 \quad (152)$$

**Result 1** *Under Assumption 4, when  $\theta$  is small the optimal portfolio decision is  $M_{h,i} = c_{0,i}$ ,  $Q_i = M_i - c_{0,i}$ .*

**Proof:** Under Assumption 4, the constraint in equation 149 is binding. Thus,

$$M_i - Q_i = c_{0,i}.$$

Consider next the optimal portfolio under the realization  $\theta = 1$  (that happens with probability  $1 - \rho$ ). In this case, consumers have no reason to supply liquidity to the financial sector, as they know for certainty that their returns to liquidity will be 0. Hence,  $M_{h,i} = M_i$  and  $Q_i = 0$ <sup>20</sup>.

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<sup>20</sup>Assuming a sufficiently large inventory guarantees that there is enough output to consume  $M_i$  goods even in the absence of production.

To summarize, in the closed economy we have that:

$$Q_i = \begin{cases} M_i - c_0 & \text{with prob. } \rho; \\ M_i & \text{with prob. } 1 - \rho. \end{cases} \quad (153)$$

Fluctuations in  $Q_i$  therefore result from fluctuations in  $\theta$  (captured by  $\rho$ ), fluctuations in the money supply and fluctuations in risk aversion (captured by  $c_0$ ). Next, I will show that liquidity supply takes the same form in the open economy.

## C.2 Liquidity supply in the integrated economy

I assume that there is a single currency, so both labor and consumption can be paid for in either domestic or foreign money. For simplicity, I assume that agents consume foreign and domestic goods proportional to their shares in output (so that, regardless of the realizations of money supplies, a unit of domestic output has the same probability of being consumed as a unit of foreign output).

As in the closed economy, agents choose between keeping money in the safe ( $M_{h,i}$ ) and buying stocks ( $Q_i$ ). In the integrated economy, a stock is a claim on the sales revenues of the global economy. After portfolio decisions are made, the global financial system distributes liquidity between foreign and domestic projects in an output maximizing way<sup>21</sup>.

**Assumption 5**    1. *The value of  $\theta$  is perfectly correlated across regions, that is, with probability  $\rho$  in both regions  $\theta$  is small, and with probability  $1 - \rho$  in both regions  $\theta = 1$ .*

2. *When  $\theta$  is small (with prob.  $\rho$ ), shocks to the ability of the productive sector to make monetary transfers are i.i.d. across regions.*

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<sup>21</sup>In this model, it is implicitly assumed that consumption is always less than output, and that there are some units of output which are ex-post “wasted”. A natural question is therefore why the global financial system allocates liquidity between foreign and domestic projects in an output maximizing way. If we think of the global financial system as a monopoly, this indeed need not be the case; however, a more competitive structure (for example, one in which the financial system is composed of many small banks competing for liquidity) would deliver this result, as the expected real value of a unit of produced output is positive.

### C.2.1 Equilibrium

I begin by characterizing the equilibrium in the case that  $\theta$  is small in both regions (an event that occurs with probability  $\rho$ ).

**The portfolio decision.** Because there is a positive probability that both economies suffer a simultaneous collapse (an event that happens with probability  $\theta^2$ ), similarly to the closed economy case the agent will reserve at least enough money to finance  $c_{0,i}$  units of consumption:

$$M_{h,i} \geq c_{0,i} \quad (154)$$

Denote by  $d$  the realized dividend per share of the global productive sector, and let  $Q_i^0$  be the equilibrium level of liquidity supplied by country  $i$  which the individual agent takes as given. Similarly to the closed economy, agents solve:

$$\max_{Q_i, M_{h,i}} c_i - v_i(L_i) \quad (155)$$

s.t.:

$$M_i = Q_i + M_{h,i} \quad (156)$$

$$c_i = \begin{cases} M_{h,i} + Q_i d + w_i L_i & \text{with prob. } (1 - \theta); \\ M_{h,i} + Q_i d & \text{with prob. } (1 - \theta)\theta; \\ M_{h,i} & \text{with prob. } \theta^2. \end{cases} \quad (157)$$

$$M_{h,i} \geq c_{0,i} \quad (158)$$

Substituting in the first constraint, this problem can be rewritten as:

$$\max_{Q_i} E(Q_i d) + (1 - \theta)w_i L_i + (M_i - Q_i) - v_i(L_i) \quad (159)$$

s.t.

$$M_i - Q_i \geq c_{0,i} \quad (160)$$

The derivative of the above with respect to  $Q_i$  is:

$$E(d) - 1 \quad (161)$$



To calculate  $E(d)$ , note that positive dividends are paid unless both economies suffer a collapse. If neither suffers a collapse (an event which occurs with probability  $(1 - \theta)^2$ ), dividends per share are  $d = \frac{M_d + M_{em}}{Q_d^0 + Q_{em}^0}$ . If economy  $i$  suffers a collapse but economy  $j$  doesn't suffer a collapse (events which occur with probability  $(1 - \theta)\theta$  each), the dividend per share is positive, as consumers in region  $i$  receive some dividends from their stock holdings in region  $j$ . Expected dividends per share are therefore bounded from below by:

$$E(d) > (1 - \theta)^2 \frac{M_d + M_{em}}{Q_d^0 + Q_{em}^0} \quad (162)$$

**Assumption 6** *With probability  $\rho$ , the value of  $\theta$  is sufficiently small so that for any realization of  $M_i$  and  $c_{0,i}$ , the following inequality holds:*

$$(1 - \theta)^2 \frac{M_d + M_{em}}{(M_d - c_{0,d}) + (M_{em} - c_{0,em})} - 1 > 0 \quad (163)$$

**Result 2** *Under Assumption 6, the optimal portfolio decision when  $\theta$  is small is  $M_{h,i} = c_{0,i}$ ,  $Q_i = M_i - c_{0,i}$ .*

**Proof:** Under Assumption 6, the derivative of equation 159 with respect to  $Q_i$  is positive at  $Q_i^0 = M_i - c_{0,i}$ :

$$E(d) - 1 > (1 - \theta)^2 \frac{M_d + M_{em}}{Q_d^0 + Q_{em}^0} - 1 = (1 - \theta)^2 \frac{M_d + M_{em}}{(M_d - c_{0,d}) + (M_{em} - c_{0,em})} - 1 > 0 \quad (164)$$

Thus, the constraint in equation 160 is binding, so  $M_i - Q_i = c_{0,i}$ .

Next, consider the equilibrium given the realization  $\theta = 1$ . In this case, there are no returns from providing liquidity to either the domestic or foreign productive sector. As in the autarkic case,  $Q_i = 0$ ,

**Corollary 3** *Both under autarky and under financial integration, the liquidity supply of country  $i$  is given by:*

$$Q_i = \begin{cases} M_i - c_0 & \text{with prob. } \rho; \\ M_i & \text{with prob. } 1 - \rho. \end{cases} \quad (165)$$

**Assumption 7** *The money supply,  $M_i$ , and the risk aversion parameter,  $c_{0,i}$ , are perfectly correlated across regions and follow time invariant distributions.*

Since equilibrium liquidity supply takes the same form both in the integrated economy and under autarky, and the shock to  $\theta$  is perfectly correlated, it follows trivially that the assumptions I make on the distribution of liquidity supply are satisfied.